Levington Research Station

1960

LEVINGTON
RESEARCH STATION
1960

Levington
Ipswich
Suffolk *Ipswich 76911*

FISONS FERTILIZERS LIMITED

LEVINGTON RESEARCH STATION

Director:

J. A. STORROW, M.Sc.TECH., PH.D., D.Sc.(MANCH.), M.I.CHEM.E.

Deputy Director:

J. G. HUNTER, B.Sc., PH.D.(GLAS.), F.R.I.C.

DEPARTMENT OF CHEMISTRY

Head of Department — J. R. ARTHUR, M.A., B.Sc.(OXON.), PH.D.(LOND.), F.R.I.C.

Co-ordination

Chief Chemist — T. P. DEE, B.Sc.(LOND.), F.R.I.C., M.I.CHEM.E.

Basic Research Group

Chief Physical Chemist — E. J. SMITH, B.Sc.(LOND.), PH.D.(DUNELM.), A.R.I.C.

Fundamental Research Section 1

Senior Chemist — F. W. BENNETT, B.A., PH.D.(CANTAB.)

Chemists — R. J. CAVE, M.A.(OXON.)
D. C. HARPER, B.Sc., PH.D.(LOND.)
K. F. J. THATCHER, B.Sc., PH.D.(LOND.)
* * * *

Fundamental Research Section 2

Senior Chemist — K. S. BARCLAY, B.Sc., PH.D.(BIRM.)

Chemists — J. M. CREWE, B.A.(OXON.)
R. F. ENEFER, B.Sc.(NOTT.)
* * * *

Physicist — R. V. COATES, B.Sc., PH.D.(BRIST.), A.INST.P.
* * * * (2)

Analytical Section

Senior Chemist — W. C. HANSON, A.R.I.C.

Chemists — I. JOHNSTON, A.R.I.C.
D. J. LLOYD
J. MCMILLAN, B.Sc.(BIRM.), A.R.I.C.
* * * *

* * * * Appointments to be made in the Station

Process Research Group

Chief Chemist — T. P. Dee, B.Sc.(Lond.), F.R.I.C., M.I.Chem.E.

Manufacturing Laboratory Section

Senior Chemist — R. J. Nunn, B.Sc.(Lond.), A.R.I.C.

Chemists — J. K. Bradley, M.Sc.(Lond.), A.R.I.C.
H. F. Godson, B.Sc.(Edin.)
R. E. Jewell, M.Sc.(Lond.), A.R.I.C.

Chemical Engineering Section

Chief Chemical Engineer — W. F. Sheldrick, B.Sc., M.Sc.(Dunelm.), A.M.I.Chem.E.

Senior Chemist — G. G. Brown, B.Sc.(Lond.)

Chemical Engineers — G. T. Dee, B.Sc.(Eng.) (Lond.)
S. M. Janikowski, B.Sc.(Eng.) (Lond.)

Chemists — D. H. Booth, B.Sc.(Hull)
G. N. Quinton, B.Sc.(Lond.)
N. Robinson, B.Sc.(Lond.)
R. G. Wilson, B.Sc.(Lond.)

BRAMFORD DEVELOPMENT STATION

Manager — S. J. Porter, B.Sc.(Manch.), M.S.(Pittsburgh), F.R.I.C., M.I.Chem.E.

Chemical Engineering Section

Chief Chemical Engineer — G. A. Turner, B.Sc., Dip.Chem.Eng.(Lond.), Ph.D.(Manch.), A.M.I.Chem.E.

Chemical Engineers — R. M. Dannatt, B.Sc.(Wales), B.A.(Cantab.), A.R.I.C.
R. W. Silvester, B.Sc.(Lond.), A.M.I.Chem.E.

* * * *

Process Development Section

Senior Chemical Engineer — C. N. Silvester, B.Sc.(Sheff.), A.M.I.Chem.E.

Chemical Engineers — W. G. Masson, B.Sc.(Birm.)
W. A. White

Chemist — J. M. Clarke, B.Sc.(Birm.)

Special Fertilizer Section

Senior Experimental Officer — R. W. Palmer

Laboratory Section

Senior Chemist — J. W. Fox, B.Sc.(Lond.), A.R.I.C.

Chemist — D. B. Ratcliffe, A.R.I.C.

Engineering Section

Senior Mechanical Engineer — R. M. Bolt, B.Sc.(Dunelm.), A.M.I.Mech.E.

DEPARTMENT OF SOIL SCIENCE

Head of Department — J. G. Hunter, B.Sc., Ph.D.(Glas.), F.R.I.C.

Agronomic Group

Agriculture Section

Chief Agriculturist	J. A. Birch, B.Sc.(Leeds), N.D.D.
Senior Agriculturist	J. D. Whitear, M.Sc., Dip.Agr.(Reading), M.A.(Cantab.)
Senior Field Officers	A. M. Ainsley, N.D.A. F. W. Dunnett, N.D.A., N.D.D.
Agricultural Economist	F. J. Orton, B.Sc., Dip.Agr.(Leeds), B.Litt.(Oxon.),
Agricultural Advisers	J. M. Coull, B.Sc.(Nott.) J. D. Edward, C.D.A. I. R. English, M.C., M.A.(Cantab.) W. K. Letheren, N.D.A. W. A. G. Mason, B.Sc.(Reading)
Farm Manager (Levington)	J. T. Pemberton, B.A. (Cantab.)

Grassland Research Section (North Wyke Experimental Station)

Senior Grassland Officer	P. G. Shaw, B.Sc.(Reading)
Grassland Research Officers	J. S. Brockman, B.Sc.(Lond.), Ph.D.(Dunelm.) Miss K. M. Wolton, M.Sc.(Agr.) (Lond.)
Grassland Experimental Officer	P. E. J. Gwynn, N.D.D.
Field Officer	D. W. T. Brough, M.A.(Cantab.)
Field Experimental Officer	* * * *
Farm Manager	R. H. Pelly, B.A.(Cantab.)

Grassland Research Consultant:
Professor J. D. Ivins (University of Nottingham)

Horticulture Section

Chief Horticulturist	O. B. Orchard
Horticultural Experimental Officer	S. B. Tree, N.D.H.
Horticultural Advisers	P. S. Atkins, B.Sc.(Nott.) J. C. Bush, B.Sc.(Reading) G. A. V. Ellis, N.D.H. C. Evans, B.Sc.(Reading) C. P. Quarrell, B.Sc.(Reading), N.D.H.
Turf Adviser	D. J. Allott, B.Sc.(Lond.)

Field Experimental Section

Chief Field Experimental Officer	J. R. Devine, B.Sc.(Agr.) (Glas.), N.D.A.
Senior Field Experimental Officer	M. R. J. Holmes, M.A., Dip.Agr.(Cantab.)
Field Experimental Officers	R. S. Adamson, B.Sc.(Agr.) (Dunelm.), A.R.I.C. H. R. Dally, N.D.H. J. Davison, B.Sc.(Agr.) (Dunelm.), Ph.D.(Nott.) D. E. J. Thomas, B.Sc.(Agr.) (Wales), S.D.A., S.D.D., N.D.D.

Statistics Section

Senior Statistician	J. C. Dickins, M.A., Dip.Stat.(Cantab.)
Statistician	* * * *

Analytical Section

Senior Soil Analyst	J. Hislop
Senior Soil Analyst	E. E. Jusa, D.Phil.(Vienna)

Fundamental Group

Soil Chemistry Section

Chief Soil Chemist	S. Larsen, B.Sc.(Agr.), Lic.Agr.(Copenhagen)
Soil Chemists	I. J. Cooke, B.Sc., Ph.D.(Leeds), A.R.I.C. M. N. Court, B.Sc., Ph.D.(Brist.) A. V. Flegmann, Dip.Agr.(Budapest) D. Gunary, B.Sc.(Nott.) D. J. Parton, B.Sc.(Wales)

Biochemistry Section

Senior Biochemist	F. E. G. Harrap, B.Sc., Ph.D.(Lond.), D.I.C., A.R.C.S.

Biology Section

Senior Biologist	R. C. Stephen, B.Sc., Ph.D.(Aberdeen)
Biologist	J. S. Waid, B.Sc.(Lond.), B.Sc., D.Phil.(Oxon.)

Plant Physiology Section

Senior Plant Physiologist	P. C. Owen, B.Sc.(Wales), Ph.D.(Lond.)

ADMINISTRATION

Accountant-Secretary	C. Hancock, A.C.W.A.
Assistant Accountant	W. H. Fox, A.C.C.A.
Librarian	T. Cawley, B.A.(Sheff.), A.L.A.
Administrative Officer	D. W. Duke-Williams, M.A.(Cantab.)
Maintenance Superintendent	H. G. Horne

Assisting the Director: Chief Chemical Engineer	K. A. Sherwin, B.Sc.(Eng.) (Lond.), D.I.C., A.M.I.Mech.E., M.I.Chem.E.

FOREWORD

LEVINGTON RESEARCH STATION was established in 1957 by Fisons Limited to carry out research to the highest standards in the wide range of sciences and technologies concerned with the provision and use of nutrients for plant growth.

The correlated research programmes are designed to enable the Company to manufacture the most efficient products at the lowest cost and to support these with sound advice on their most economic use. To fulfil this design there are fundamental studies in physical and chemical sciences as well as manufacturing investigations up to the stage of works production, and along with these are basic studies and field investigations on crop nutrition and soil characteristics. Publication of results from these fundamental and applied studies will make a valuable contribution to both scientific and agricultural knowledge.

This book outlines the work that is being carried out by the Levington organization and gives some of the results that have been achieved so far.

J. A. STORROW
Director

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INTRODUCTION

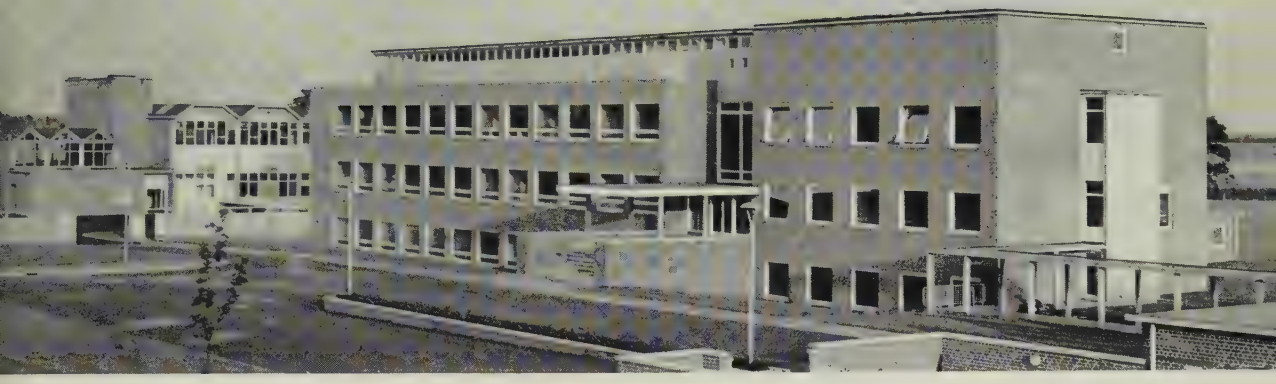
THE LEVINGTON RESEARCH ORGANIZATION consists of the Central Laboratories at Levington together with two associated farms and a horticultural unit, Bramford Development Station near Ipswich, and North Wyke Experimental Station in Devon. The administrative staff at Levington provide the services at these sites including accounting, library, and instrument and engineering workshops which are necessary in such a scientific research group of this diverse nature.

The scientific work of the organization is divided between the Department of Chemistry, the Bramford Development Station and the Department of Soil Science.

The Department of Chemistry studies the fundamental physical and chemical properties of raw materials and end-products, and the kinetics of conversion reactions. It also investigates new and improved processes for producing plant nutrients in forms which have suitable properties in manufacture, handling and use. Larger scale process investigations are transferred for appraisal to the Bramford Development Station, where suitable control laboratories, workshops and more extensive chemical engineering facilities are available. This Station also studies plant modification and operation problems in collaboration with the manufacturing works of Fisons Fertilizers Limited.

The Department of Soil Science deals with soil and agronomic problems associated with the use of fertilizers. The fundamental studies and experimental investigations of materials in the Levington laboratories, pot trials and field experiments are supplemented by extensive trials throughout the country, controlled by the central staff and conducted by provincial officers on land of co-operating farmers and growers. The grassland research section of the Department is at North Wyke.

The Levington organization employs about ninety graduates and three hundred and fifty non-graduate staff and wage-earners.

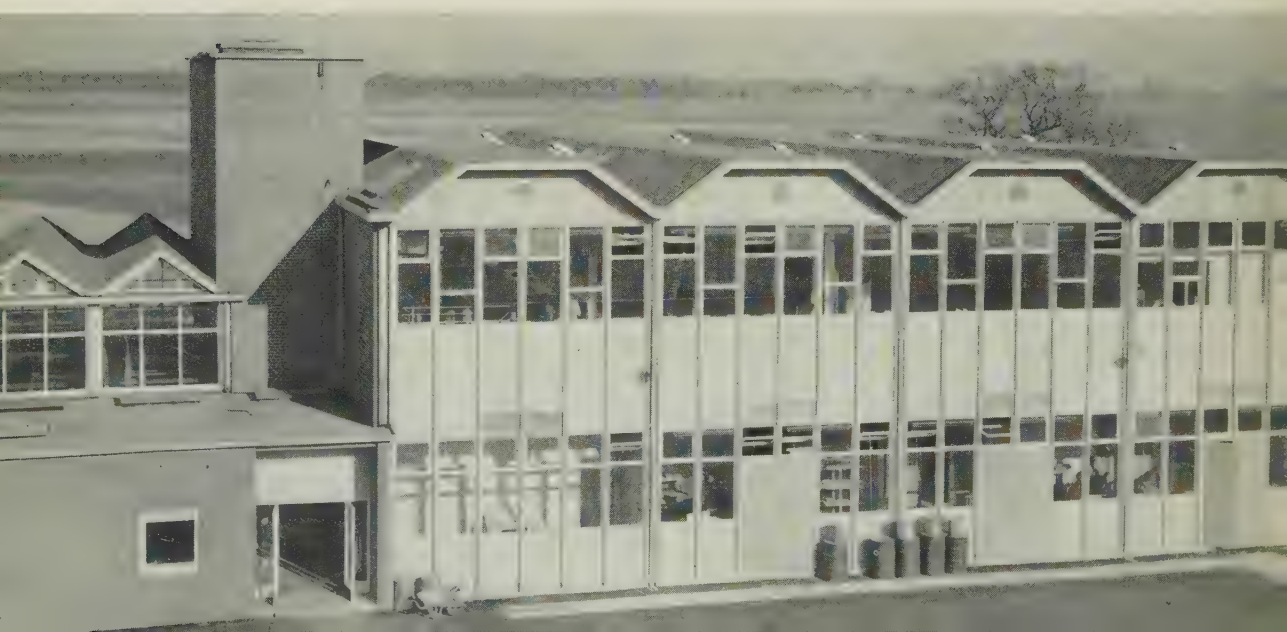


Above: The main building contains laboratories, library, conference rooms and offices.

Below: The library.

Above: The structural design of the laboratories is illustrated by this view of the analytical laboratory of the Chemistry Department.

Below: Chemical engineering studies on new and improved methods of fertilizer manufacture are carried out in the Process Laboratory.



Department of Chemistry

Two main types of problem are studied in the Department:

(a) Complete and partial manufacturing processes on the bench and semi-technical scale.

(b) Supporting work on the properties of individual and mixtures of fertilizers which influence manufacturing procedures, handling and storage properties.

The Department is composed of two main Groups whose activities are largely defined by the division of the work according to the main two problems stated above. These Groups are the Basic Research Group and the Process Research Group.

Basic Research Group

This is divided into three Sections dealing with physico-chemical research and analytical problems.

Fundamental Research Section 1. Studies are in progress of the fundamentals of granulation, the drying characteristics of granular materials, the equilibrium properties of fertilizer/moisture systems, and reaction mechanism studies in the acidulation of rock phosphate.

Fundamental Research Section 2. Present studies include kinetic studies of some thermal reactions in mixed fertilizers, the diffraction of X-rays by inorganic salts, and the thermal analysis of fertilizers.

Analytical Section. This Section is responsible for all chemical analytical work coming from the Departments of Soil Science and Chemistry dealing with fertilizers and with fertilizers incorporating additives such as pesticides. The specific determination of organic pesticide concentration in the presence of fertilizer environment creates numerous analytical difficulties, but considerable progress had been made applying chromatographic and infra-red spectrographic techniques. A balance is maintained between routine analysis and development of new analytical methods.

Process Research Group

The process research group is divided into two sections, one of which is mainly concerned with laboratory scale research and the other with semi-technical scale work in the Process Laboratory.

Manufacturing Laboratory Section. Herein investigations are carried out aiming at the continued improvement of the range of fertilizers marketed. The work is done in close collaboration with the Production Department, the Soil Science Department

and the Fundamental Research Group. Studies of portions of overall manufacturing processes are made with the particular objective of predicting large-scale behaviour. The assessment of storage characteristics forms an important part of the work and an excellent laboratory test method has been developed for this purpose.

Chemical Engineering Section. This is composed of a team of chemical engineers and chemists, the main duties are concerned with design and operation of semi-technical plant to investigate new and improved manufacturing processes: the Section is self-supporting for its analytical control work.

In both these sections, a number of fertilizers are prepared for field experiments and pot trials by the Soil Science Department.

Bramford Development Station

This Station is primarily a site for chemical engineering investigations, the main areas being pilot plant buildings with associated chemical laboratories, offices and workshops. The graduate staff are supported by teams of process operators and engineering craftsmen, providing the abilities for designing, erecting and operating pilot plant and associated instrumental control systems.

The Station is concerned with establishing new or modified techniques for the production of fertilizers. The studies on relevant operations form individual programmes which may well spring from the knowledge and interests of the staff, many of whom have had experience in the factories. Similar types of problems may be raised by the technical staff of the Production Department. The work requires close collaboration with that Department, and may also involve the Development Station staff in full-scale trials on producing units or in providing commissioning teams for new processes. Throughout their work the staff maintain close collaboration with the Chemistry Department, particularly in developments stemming from new processes and operations studied in that Department. The major studies thus range from the re-appraisal of hitherto established processes for the manufacture and handling of nutrient source materials to the investigation of novel procedures, chemical processes, physical operations and automatic control. Important subsidiary studies are concerned with improving packages for agricultural products.

Chemical Engineering Section. This Section is concerned with the more fundamental aspects of chemical engineering operations and processes. New techniques of evaluation are sought, particularly those having a bearing on plant control, involving transient response studies and techniques of continuous sampling, measurement and analysis of the plant streams in production processes.

Process Development Section. The main process pilot plant activities are controlled and studied by this Section, e.g. the translation of physico-chemical kinetic studies from the Chemistry Department into preferred operating conditions to guide manufacturing units by the provision and study of appropriate model plants. The staff maintain a range of pilot facilities covering the normal manufacturing processes of the Company, as well as those for studying novel methods.

Special Fertilizer Section. Many special fertilizers for the work of the Soil Science Department are made at the Development Station by this Section, which for this purpose operates granulating and drying plants with capacities up to 2 ton/hour of products. The first process assessment of new formulations is made by the staff from their experience of present manufacturing methods, to recommend operating conditions for larger scale work.

Laboratory Section. This Section provides the control analyses for all activities at the Development Station, and in addition studies methods of analysis and assessment of phosphate rock reactivities.

Engineering Section. The provision and maintenance of various pilot plants and services require extensive engineering facilities. The Section also controls certain physical testing methods for materials associated with fertilizer manufacture, storage and handling.

Department of Soil Science

The Soil Science research programme is designed to advance knowledge of soil and agronomic problems especially in relation to fertilizer usage. The long-term study of fundamental principles is important, but many problems of more immediate concern are also considered. Laboratory studies, pot and field investigations are closely integrated.

Agronomic Group

This Group is concerned with applied studies which are principally field and pot investigations related to fertilizer usage. Fertilizer recommendations made by the Company are based on the results of field experiments carried out by Levington and other research organizations with which close liaison is maintained.

Investigations examine the relative agronomic efficiency of nutrient sources derived from different raw materials and methods of manufacture, and are concerned also with the time and rate of application of nutrient materials as well as associated subjects including minor element significance and the use of insecticides and herbicides incorporated in fertilizers.

The Group consists of four Sections directly concerned with these applied studies and two Sections which primarily have service responsibilities to the Department as a whole.

Agriculture Section. The two farms at Levington are the responsibility of this Section and their prime requirement is to provide facilities for fertilizer experimentation on agricultural crops. Farming as an enterprise often has to be secondary.

The land at Levington is predominantly light with low rainfall, especially in the spring. This contrasts with the Grassland Research Section farm at North Wyke which is a heavy-soil farm in a wet area. These soil and climatic facilities are substantially expanded by eight Agricultural Advisory and Field Officers, who carry out the provincial field experimental programme assisted by Recorders. In this way the variations in soil, climate and farming systems that occur in British agriculture are adequately covered.

These provincial officers are also available as specialists working in co-operation with the Technical Advisory Service for advising farmers and can refer field problems that require special research investigation to Levington.

Grassland Research Section (North Wyke Experimental Station). This Section, stationed in Devon, is responsible for research on the production and utilization of grass especially in relation to fertilizer usage. It is also responsible for the management of the farm. In addition to replicated plot experiments in which grass production is measured by harvesting and weighing, animal experiments are being carried out. Fertilizer responses in grass under pasture management are measured and pasture quality differences examined in terms of milk production, liveweight gain and digestibility. The requirements of the grassland research programme will largely determine the farm policy at North Wyke. The Section is also responsible for co-ordinating the grassland experimental programme at Levington and in the provinces.

Horticulture Section. In the sixty-acre Horticultural Unit at Levington, all crops are produced entirely for research. In this, the Section collaborates with the Field Experimental staff, thus ensuring that experimentally valid results are related to crops produced to the highest standards of cultivation. Projects on fertilizers, insecticides, herbicides and fungicides are all included in the research programme.

Nine glasshouses, constructed and operated according to normal commercial practice, cover half an acre. These houses, all under experimentation, are planted with tomatoes, cucumbers and carnations. Twenty-eight acres of apples and pears are grown on the delayed open-centre method and most of this area will not be under experiments until the trees are fully established. Experiments on vegetables occupy about one acre each year. Four acres of fine turf are available and investigations are

proceeding on a wide variety of subjects. A two-acre unit planted with a wide range of flowers, vegetables, fruit, shrubs and trees provide facilities for research mainly for products sold in the amateur market.

The Section has a complement of eight, comprising an Experimental Officer, a Turf Adviser and general Horticultural Advisers who are stationed at Levington and in the provinces.

Field Experiment Section. Experiments on agricultural and horticultural crops at Levington are the responsibility of the Section which also collaborates with the Agriculture Section in carrying out experiments sited in East Anglia and the South East. The facilities at Levington enable more detailed experiments to be carried out than is possible in provincial experiments sited on the land of co-operating farmers, including the introduction of the animal factor. The Section is responsible for the techniques used in all the field experiments, to ensure that results are not influenced by variation in technique and to improve the experimental methods used. Machines designed specifically for experimental work are investigated by the Section.

The Pot Trials Unit consists of a preparation building, a large covered cage, a Dutch Light structure and six Hartley glasshouses, where heat and additional artificial illumination are available. Pot experiment facilities are made available to other Sections of the Department.

Statistics Section. Field and pot trials are designed and a computing service for the statistical reduction and analysis of data is provided. Experimental techniques are investigated statistically and advice is given on problems of a more general mathematical nature.

Analytical Section. Soil and crop samples are taken through routine analysis at a rate of 60,000 samples annually. Of these samples 31,000 form part of the advisory service to farmers and growers, the remainder being derived from research investigations. Considerable attention is being devoted to the application of mechanization and automation techniques to facilitate these analyses.

Fundamental Research Group

This Group is concerned with fundamental studies on the relationship between soil, nutrients and crop growth.

The main field of research is soil phosphorus, the interactions between applied phosphorus and the soil, and the relationship of these to crop production, for despite its importance, the existing knowledge of the fundamental aspects of the plant-soil-phosphorus relationship is at a relatively elementary stage. The study requires co-ordinated research from the four Sections of this Group, though each Section has its own special approach.

Although phosphorus receives most attention, other topics studied include the loss of nitrogen as gaseous ammonia from the soil after application of nitrogenous fertilizers, the effect of environmental factors, particularly soil water, on plant growth, and the relationship between plant nutrition and disease incidence.

Soil Chemistry Section. Soil phosphorus systems are extremely complex and in order to simplify their study they are being approached in this Section from three complementary aspects which, when integrated, will provide a more complete understanding of the whole. These aspects comprise a capacity factor, an intensity factor, and a kinetic factor. As reference material for use where necessary in these studies, twenty-three British soils were enriched in 1957 with 500 lb. and 1,000 lb. water-soluble P_2O_5 per acre; these also allow the fate of applied phosphate to be followed on the above lines.

In considering the capacity factor, a suitable method for the determination of total soil phosphorus has been developed and various techniques are being used to divide this into its components. The labile soil phosphorus is measured by isotopic dilution, either in pot experiments (L-values), or laboratory experiments (E-values). Past experiments have examined the importance of technique details in L-value estimations and in addition, the L-values of the enriched soils have been measured for two successive seasons; from average figures it appears that a large proportion of the applied phosphate has remained labile. A technique for E-value measurement has been developed and a comparison has been made with L-values on a few selected soils. Isotopic dilution techniques have been used in conjunction with measurement of total inorganic phosphorus; an extension of this technique will be used to categorize inorganic phosphate into various groups. A study is also being made of interactions between inorganic phosphate and soil organic matter.

Phosphate potential measurements (the intensity factor) have been made on the enriched soils and have shown that the phosphate potential was influenced by the level of phosphate enrichment. The influence of plant growth on phosphate potential has also been assessed.

Phosphate reaction rates and phosphate mobility together constitute the kinetic factor and techniques to further this study are being developed.

A subsidiary investigation is that of ammonia loss when nitrogenous fertilizers are applied to soils. This is being considered both fundamentally and agronomically.

Biochemistry Section. Emphasis is placed on studying the effects on soil and applied phosphorus of incorporating organic matter in the soil and a large part of the investigation has so far been concentrated on the analytical techniques required for the determination of total and inorganic phosphorus in water extracts of soils and in solutions after electrodialysis. Results using some of the usual methods were

unsatisfactory but a suitable method for the determination of the small amounts of phosphorus in these water extracts is now in use. Electrodialysis of soil-plant mixtures have been carried out and determinations made of the radioactive phosphorus recovered from the plant residues used in the mixtures.

Techniques for the production of ryegrass have been developed so as to obtain roots free from soil and from possible contamination by radioactive phosphorus when applied to soil containing it. Satisfactory methods have also been evolved for incubation of soil and soil-root mixtures and a number of experiments have been made to determine the time taken for the level of water-soluble phosphorus to be stabilized after the addition of water and of inorganic phosphorus to the mixtures.

A project for the automatic extraction of water-soluble phosphorus, the determination of radioactive phosphorus in the solution obtained and a fractionation of the extracts is being developed. A method for the determination of soil organic phosphorus in air-dry soils using successive extractions with sodium EDTA and caustic soda has been very satisfactory. Chromatographic techniques for the determination of the phosphorus compounds in water extracts of soil are also being investigated.

Biology Section. The Section is mainly concerned with the relationship between soil micro-organisms and soil and applied phosphorus and between host nutrition and disease incidence. Research on the former is in the early development phase but considerable progress has been made on technique development and projects are being carried out on the relative efficiency of various phosphates for plant and microbial growth.

Field experiments have indicated that decreases in potato blight disease on the foliage are associated with increase in rate of nitrogen and potash application and other data suggest that this may be related to the effects of plant nutrient application on plant development. The effects of nutrient application to the soil and foliar application of nitrogen on plant growth and chemical composition are being examined.

Preliminary results from winter wheat field experiments show that whilst phosphate and potash applications to the seedbed have no effect on the incidence of take-all disease, increase in the rate of applied nitrogen considerably reduced stand losses and gave increased yields as a result. Nitrogen applied in the autumn had little effect, but spring applications considerably reduced the damage, early applications being more effective than late ones.

Plant Physiology Section. The influence of phosphorus on plant growth and development, and the influence of the environment on nutrient absorption by plants, are being investigated by two parallel methods.

The first depends on the techniques of Growth Analysis, using the concept of Net Assimilation Rate, where successive samplings are made of crops grown either in small plots or in water culture. Phosphorus/water interaction effects on the growth of sugarbeet will be examined in plot experiments in a Dutch Light structure which has been built for experiments in which water regimes can be controlled and their interactions with applied nutrients considered. Preliminary work on the growth of sugarbeet and barley has been conducted in a new water culture installation.

The second method of investigation uses an infra-red gas analyser for the direct measurement of photosynthesis and respiration rates of plants. The speed of response of plants to changes in water-soluble phosphates at their roots and the particular nutrient requirements at different stages of growth, are being studied in water culture.

In the laboratory, development work is continuing on a method based on the Peltier effect for determining soil pF values from equilibrium relative humidities.

Levington Farms

The two farms at Levington are designed and operated to provide facilities for fertilizer experiments on farm crops. They occupy three hundred and thirty-five acres which formerly would have been described as 'sheep and barley' land. It is predominantly light loam of glacial origin overlying sand and gravel situated on the plateau between the Deben and Orwell estuaries in Suffolk.

The annual rainfall ranges from about fifteen to thirty inches, but with long periods of drought, particularly in the spring. For example, the rainfall in 1959 was 15.7 inches but there was less than six and a half inches between March and September and only five inches between March and July.

Walk Farm and Red House Farm were purchased in October, 1953. During 1954 and 1955, many changes were carried out; rabbit-infested banks between fields were bulldozed out, superfluous fences removed and scrub eliminated. In addition, hedgerows and five shelter belts were planted, and at Red House Farm all fields were refenced. At Walk Farm, where the only buildings were two open cattle yards and a tithebarn, three new buildings were erected to give tractor, implement and workshop accommodation, a fertilizer store, grain drying and storage facilities, and covered cattle yards for winter beef production. In 1956 a further building was completed at Red House Farm, comprising a milking parlour and dairy, two covered yards with feeding passage, implement shed and dutch barn storage, all under one roof. Early in 1957 a range of old buildings at this farm was reconstructed to make loose boxes, calf pens, a meal barn and an open yard. There are walled pit silos at both farms.

WALK FARM – 235 acres

Owing to the uniformity of soil type, this farm is very suitable for fertilizer experiments and large-scale trials. After two initial cropping years to assess this uniformity, Walk Farm has been developed into five specific areas.

Area II. The cropping and fertilizer policy on this area of over fifty acres is designed to give each year a different weed-free experimental area with a low nutrient status. This is required for the critical comparison of different sources of fertilizer produced, for example, from different raw materials or by different methods of manufacture. It is only under these conditions that appropriate variation in crop performance can be detected. If any differences are shown up under these conditions, the sources are further examined on 'normal' soils.

The area is cropped on a six-course rotation (one break of which is used for experiments) as follows:

	Crop	Fertilizer	Rate Cwt/acre	Remarks
A.	Winter wheat	Farmyard manure	15 tons	Experiments 1957
		Nitrogen (S/A)	5	
B.	Clover	None	—	Experiments 1958
C.*	Barley undersown	Nitrogen (S/A)	1½	Experiments 1959
D.	Annual experiments	Experimental	—	—
E.	1. Potatoes	Nitrate of Potash	3	Experiments 1961
	2. Kale	Nitrogen (S/A)	3	Experiments 1961
		Nitrate of Potash	3	
F.	Sugarbeet	Nitrogen (S/A)	4	Experiments 1962
		Nitrate of Potash	2	

*C = C_1 and C_2 (*see map*)

Farmyard manure is applied once in the rotation to ensure that the soil structure does not deteriorate to the detriment of experimental results, and lime if necessary is applied on the furrow prior to drilling wheat. The timing of these applications is such that they will cause minimum interference with the experiments.

Nitrogen is applied at rates to ensure full crops except on the potatoes and kale where the rates are well below the normal uptake by these crops in order to minimize any chance of excess residual nitrogen that would interfere with nitrogen experiments in the succeeding year. Potatoes, sugarbeet and kale have a high potash requirement and a small amount is given to prevent crop failure.

Soil analyses and a response trial in the previous year are both used to assess the soil reserves of available plant nutrients for the 'experimental' break in the rotation.

Potatoes and kale are both grown in the year preceding experiments, so that when potatoes are required for these experiments they can follow the kale and avoid having the same crop for two successive seasons. This rotation, designed for experimental purposes, may be further modified as a result of information gained from rotation experiments carried out on Area 12.

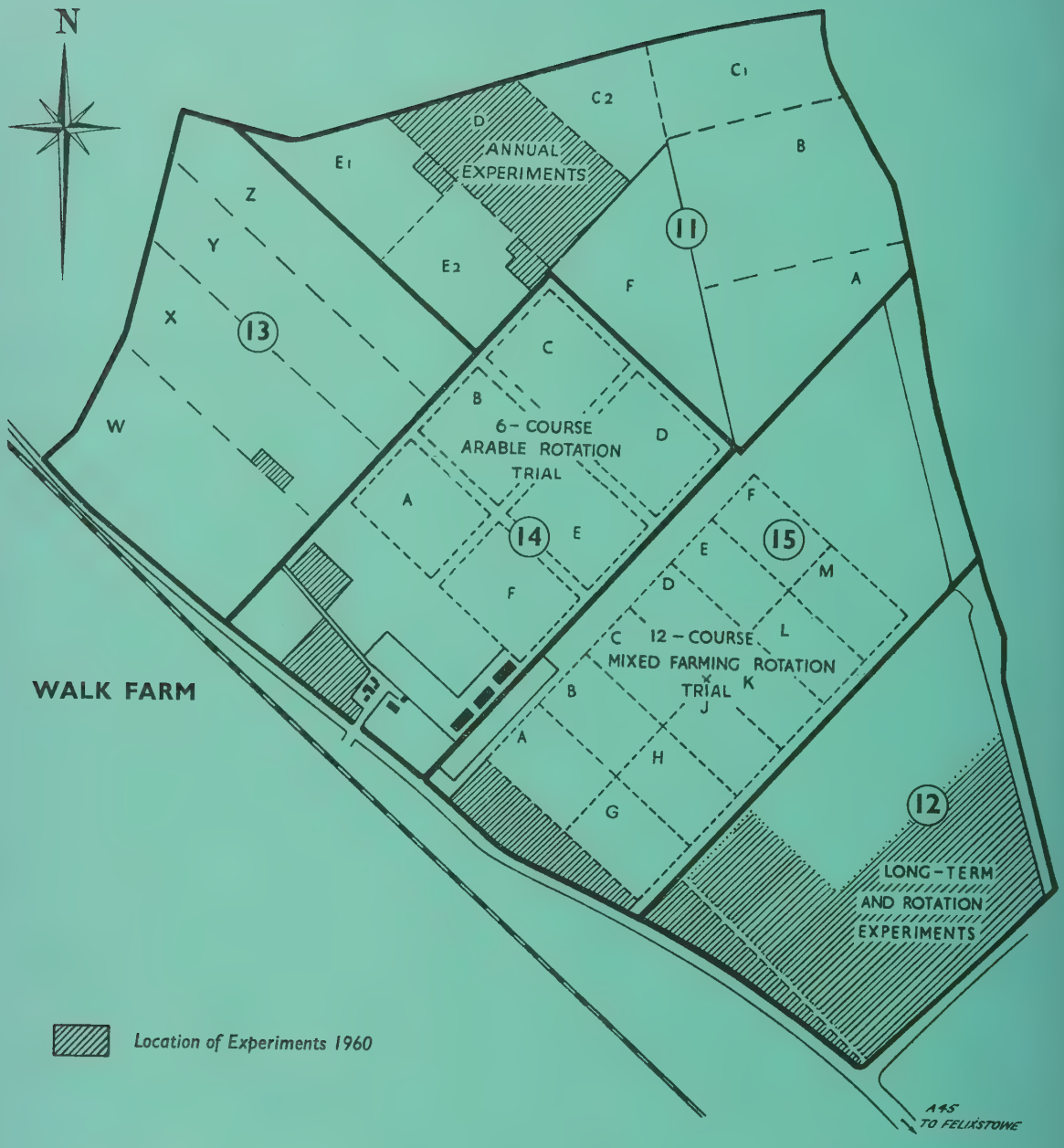
Area 12. Part of this area is used for long-term and rotation experiments that are put down for an indefinite period, and part is reserved for future experiments.

Area 13. This thirty-five acre area is farmed on a four-course arable rotation of peas, wheat, sugarbeet, barley, and is used for fertilizer experiments on arable crops for which the 'low nutrient' status of Area 11 is not necessary. If potatoes are required, they may be substituted for part of the sugarbeet break.

Area 14 and Area 15 – Large Scale Trials. About seventy acres of these two areas are devoted to two large-scale trials consisting of a six-course arable rotation and a twelve-course mixed farming rotation.

The objects of these trials are to determine the most economic compound fertilizer levels under Levington conditions on two rotations representing different farming systems and to assess the residual value of these fertilizers on subsequent crops.

The parts of these areas not occupied by the large scale trials are available for annual experiments but otherwise they are farmed in a normal way. A small acreage of maize is being grown as a fodder crop for silage.


N
WALK FARM
D
ANNUAL EXPERIMENTS
C2
C1
B
E1
E2
Z
Y
X
W
13
11
F
A
C
B
D
6-COURSE ARABLE ROTATION TRIAL
A
14
E
F
15
F
E
D
M
C
12-COURSE MIXED FARMING ROTATION TRIAL
L
K
J
B
A
H
G
12
LONG-TERM AND ROTATION EXPERIMENTS
Location of Experiments 1960
A45 TO FELIXSTOWE

Cropping and Fertilizers 1960

Area No.	History	Crop	Fertilizers Type	Fertilizers Rate cwt/acre
11	**Restricted Fertilizer Rotation**			
A	1959 Red Clover	Winter wheat	FYM	15 tons
			S/A	5
B	1959 Barley undersown	Red clover	—	—
C_1 C_2	1959 Experiments	Barley undersown	S/A	$1\frac{1}{2}$
D	1959 Potatoes; Experiments	Experiments	Experimental fertilizers	
E_1 E_2	1959 Sugarbeet	Potatoes	N/P	3
		Kale	N/P	3
			S/A	3
F	1959 Winter wheat	Sugarbeet	N/P	2
			S/A	4
12	**Long-term Experiments** since 1956	Experiments	Experimental fertilizers	
	1959 Barley, 1958 Sugarbeet	Potatoes	FYM	10 tons
			N/P	2
			S/A	5
13	**Normal Fertilizer Rotation**			
W	1959 Peas	Winter wheat	45 plus Aldrin	3
	1958 Experiments		S/A	5
X	1959 Winter wheat; Experiments	Sugarbeet	42	8
	1958 Fallow (sugarbeet failed)		Salt	2
Y	1959 Sugarbeet	Barley	42	4
	1958 Barley			
Z	1959 Barley	Peas	47	3
	1958 Barley			
14	**Arable Rotation Trial** since 1956	Arable Rotation Trial	*See p. 22*	
	1959 Experiments, 1958 Kale	Experiments	Experimental fertilizers	
	1959 Experiments, 1958 Kale	Kale	41	10
	1959 Kale, 1958 Kale	Potatoes	41	12
15	**Mixed Farming Rotation Trial** since 1956	Mixed Farming Rotation Trial	*See p. 23*	
	1959 Potatoes, 1958 Peas	Barley	S/A	3
	1959 Kale, 1958 Kale	Experiments	Experimental fertilizers	
	1959 Kale, 1958 Barley	Maize	FYM	10 tons
			Various	Various

Abbreviations: M/P muriate of potash (60% K_2O), N/P nitrate of potash (15% N, 10% K_2O), S/A sulphate of ammonia (21% N).

Compound Fertilizer Analyses:	N	P_2O_5	K_2O
Fisons 41	10	10	18
Fisons 42	16	9	9
Fisons 45	6	15	15
Fisons 47	0	14	28

Arable Rotation Trial. This trial was started in 1956 on Area 14 and the rotation is:

Potatoes, Peas, Winter Wheat, Sugarbeet, Barley, Winter Barley.

The three fertilizer levels applied are designed to straddle the normal commercial compound fertilizers that are recommended. These levels are described as low, medium and high, the medium level being that usually recommended.

The fertilizer levels applied, in cwt/acre, are as follows:

Area 14 (*see Map*)

	Crop	Fertilizer	Low	Medium	High
F.	Potatoes	41 plus Aldrin	6	12	18
A.	Peas	47	0	2	4
B.	Winter wheat	45 plus Aldrin	1½	3	4½
		S/A (in spring)	3 on half of each 'third'		
C.	Sugarbeet	49	4	7½	11
D.	Barley	42	1½	3	4½
E.	Winter barley	45	1	2	3
		S/A (in spring)	1	2	3

Each break is of approximately four acres, divided into randomized 'thirds' for the three fertilizer levels. With potatoes and sugarbeet these thirds are applied at right angles to the way they are applied on the other breaks, so that there are nine plots on each break, each harvested separately. After a number of years it might be possible from these results to say, for example, that it would have paid a farmer best to have applied the medium level in the case of sugarbeet but it would have been worth his while to apply the high level in the case of potatoes. It must be remembered that these conclusions apply to Levington conditions as far as the growing aspects are concerned but are also dependent on the market price obtained, which is outside a farmer's control.

Some indication of the residual values can also be gained by considering, for example, pea yields following potatoes. The high level on potatoes may leave sufficient plant foods in the soil so that only the low or medium level is necessary for the peas.

Mixed Farming Rotation Trial. All breaks in this trial were established by 1959 under the following rotation:

Winter Wheat, Sugarbeet, Barley (undersown), 3 years Lucerne, Kale, Barley, Barley (undersown), 3 years Timothy/Meadow Fescue/clover ley.

As in the case of Arable Rotation Trial, three fertilizer levels are applied (cwt/acre) as follows:

Area 15 (*see Map*)

	Crop	Fertilizer	Low	Medium	High
A.	Winter wheat	45 plus Aldrin	1	2	3
		S/A (in spring)	1½	3	4½
M.	Sugarbeet	49	4	7½	11
L.	Barley (undersown)	47	1	2½	4
		S/A	1	1	1
K.	Lucerne – 1st year	47	2	4	6
J.	2nd year	47	2	4	6
H.	Red clover 3rd year (Lucerne failure 1st year)	—	—	—	—
G.	Kale	41	4	8	12
		S/A	0	2	4
F.	Barley	42	2	3½	5
E.	Barley (undersown)	47	1	2½	4
		S/A	1	1	1
D.	Grass/clover ley – 1st year	S/A	0	1½	3
C.	2nd year	47	0	1½	3
		S/A	0	1½	3
B.	3rd year	S/A	3	3	3

The percentage composition of the fertilizers used in these rotation trials is as follows:

	N	P_2O_5	K_2O
Fisons 41	10	10	18
Fisons 42	16	9	9
Fisons 45	6	15	15
Fisons 47	0	14	28
Fisons 49	14	6	20
Sulphate of ammonia		21% N	

Each break is of approximately two and a half acres, again divided into randomized thirds for the three fertilizer levels. The fertilizer levels on the arable crops are applied at right angles to the way they are applied to the leys and lucerne. For the arable crops, there are nine plots, each harvested separately, so that the residual effect of the fertilizer levels applied to the leys can be measured. The ley and lucerne breaks are cut or grazed in their respective thirds.

As in the Arable Rotation Trial, information will be obtained on economic levels of fertilizer application. In addition, the nutritional contribution made by these leys to subsequent arable crops will be assessed.

Livestock. Sheep and cattle are required for some experiments and for the large-scale trials mentioned above.

A small flock of Suffolk ewes are kept for early lambs and these are used for grazing on the large-scale mixed farming trial. Additional sheep may be bought if the flock cannot provide sufficient for the grazing of experimental plots. Young female stock from the dairy herd at Red House Farm are also available for use in this context.

Farmyard manure is required for some agricultural experiments and also for the Horticultural Unit. The manure from the dairy herd is supplemented by dung from bullocks fed in yards.

Crop Varieties. As the development of new varieties is not the concern of Levington, those used on the farm for experiments and ordinary cropping are commercial varieties best suited to the conditions and are as follows:

Winter Wheat	Cappelle Desprez
Winter Barley	Pioneer
Spring Barley	Proctor
Potatoes	Majestic
Sugarbeet	Hilleshog 'E'
Kale	Marrowstem and Canson
Peas	Harrisons Glory

Walk Farm is primarily run to provide facilities and the right soil conditions for fertilizer experiments and trials on arable crops, but apart from certain restrictions this imposes on fertilizer levels, the land is farmed with the usual cultivations, including crop spraying. Profitable farming under these conditions is difficult and is not a primary objective, but with the cost of experiments and the additional recording on the large-scale trials discounted, a profit can be achieved.

RED HOUSE FARM – 100 acres

The soil types on this farm cover a wide range from light sand to heavy clay owing to the topography. The farm is on the edge of the plateau, between the Deben and Orwell estuaries and the main physical feature of the farm is a small valley leading down to the Orwell estuary. The result is that Red House is far less suitable on the whole for fertilizer experiments than Walk Farm. The dairy herd is used for some livestock experiments and where the soil is relatively uniform, fertilizer experiments are carried out.

The Dairy Herd and Cropping. The Red Poll herd consists of approximately forty milking cows with selected female followers and is managed on the principal of cheap milk production from home-grown bulk food supplemented by balanced concentrates to high-yielding cows.

The Red Poll herd was founded in 1956 with 10 non-pedigree cows and 10 pedigree heifers. It was decided two years later to increase the size of the herd to 40 milking cows so that a further number were bought at dispersal sales, but there are now a sufficient number of home-bred heifers available for herd replacements. A young Kirton bull was purchased in 1958 as conception rates had not been satisfactory with artificial insemination. Since then there have been few breeding difficulties.

With 33/34 cows in milk at any one time, the herd is run as a one-man unit. The herd average from the last completed lactations of the cows and heifers was approximately 750 gallons. It is hoped to raise this herd average to 900 gallons.

Accommodation is provided by a composite building including milking parlour and dairy, two covered yards, with feeding passage, implement shed and dutch barn storage for hay and straw all under one roof. In addition there is a range of loose boxes, calf pens, meal barn and open yard converted from existing old buildings.

The cropping is based on a seven-course ley farming system to provide grazing, conservation and fodder crops for the Red Poll herd. A cash crop of early potatoes, Arran Pilot, is taken after kale and the land is then sown down to a long ley. Formerly these leys were based on cocksfoot but in future they will be Timothy/Meadow Fescue/White clover mixtures. Lucerne is grown principally for silage, but the acreage has had to be reduced because of verticilium wilt. There is a small acreage of permanent pasture near the buildings.

A45
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HORTICULTURAL
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MANURIAL
REFERENCE
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RESEARCH
STATION
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4S
FARM
COTTAGES
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RED HOUSE FARM
Location of Experiments 1960

Cropping and Fertilizers 1960

Field No.		History	Crop	Fertilizers Type	Fertilizers Rate cwt/acre
1		Reseeded 1956	Cocksfoot/clover ley	M/P	1
				S/A	2 × 3
				(Restricted Fertilizer Area)	
2		Reseeded 1956	Cocksfoot/clover ley	36	3
		Reseeded 1958	Ryegrass/clover ley		
3		Seeded after early potatoes 1959	H.I. Ryegrass ley	Experimental fertilizers	
4	N	Undersown in barley 1958	Cocksfoot/Meadow Fescue/clover ley	36	3
4	S	Undersown in barley 1957	Cocksfoot/clover ley	41	4
				S/A	2 × 2
5		Kale 1959 after old pasture	Early potatoes	42	12
6		Drained; renovated 1956	Old pasture	36	4
7		Lucerne since 1956	Cocksfoot/clover ley	45	3
8		H.I. Ryegrass ley since 1957	Kale	41	10
9		Reseeded 1959	Lucerne	47	2 × 3
10		Seeded after early potatoes 1956	Cocksfoot/clover ley	41	4
				S/A	2 × 2

Abbreviations: M/P muriate of potash (60% K_2O), N/P nitrate of potash (15% N, 10% K_2O), S/A sulphate of ammonia (21% N).

Compound Fertilizer Analyses:

	N	P_2O_5	K_2O
Fisons 41	10	10	18
Fisons 42	16	9	9
Fisons 45	6	15	15
Fisons 47	0	14	28
Fisons 36	8	12	8

Manurial Reference Trial – Field 1. This is intended to illustrate visually the effects on crop growth, resulting from the presence and absence of the three major nutrients and farmyard manure on local soils. The trial consists of thirty-five plots with the following treatments:

Nil, NP, NK, PK, NPK, NPK + FYM, FYM.

These are at rates of application regarded as best suited to the normal requirements of the crops.

The crops, specially chosen for greatest visual response, are in the following rotation:

Potatoes, Sugarbeet, Barley, Red Clover, Kale

Hypomagnesaemia Investigation – Field 3. The factors affecting hypomagnesaemia in cattle and sheep are now recognized as being complex but they can be associated with the magnesium available to the animal in its feed. Supplementary feeding of magnesium compounds is commonly employed as a preventative but this investigation examines the possibility of increasing the animals' intake of magnesium by the application of magnesium compounds to the grass, the treatments being assessed by their effect on the magnesium content of the cows' blood serum over the critical early grazing season.

A relatively high incidence of hypomagnesaemia has occurred on this farm, so that it is very suitable for this investigation, which it is intended to continue over a number of years.

Above: The main buildings of Red House Farm, Levington.

Below: Some of the farm buildings erected in 1955 at Walk Farm to supplement the existing ones.

Above: The Red Poll herd is used for research on animal health in relation to nutrition. The Station can be seen in the background.

Below: The Horticultural Unit includes nine glasshouses for tomatoes, cucumbers and carnations, on which experiments are carried out.

Horticultural Unit

The Horticultural Unit consists of sixty acres planted with a range of crops to provide facilities for investigations on fertilizers, herbicides, insecticides and fungicides. Twenty-eight acres are planted with apples and pears, an area of twenty acres is available for vegetable crops, half an acre of glass is devoted to tomatoes, cucumbers and carnations, five acres of fine turf cover investigations on lawns, and two acres are planted with a complete range of plants grown in gardens. All crops are grown to the highest standards. The results obtained from research projects are, therefore, of direct interest to all commercial growers within the industry and to amateurs. The 'Wright Rain' system of irrigation is designed to cover the complete Unit, water being taken from a deep well. Irrigation is used where necessary as a normal cultural operation, but irrigation equipment will also be used for experimental purposes.

Fruit

The fruit areas on the Horticultural Unit were cropped with farm crops prior to 1955 when present development was started. The soil is mostly fine, sandy loam overlying coarse loamy sand, although near the south-eastern corner of the apple orchards there is an area of heavier soil. Initially sub-soiling was carried out to break up a plough pan. Planting of top fruit and blackcurrants took place in November 1955.

Apples and Pears. Fifteen acres of dessert apples planted twenty feet square consist of three main varieties – Cox's Orange Pippin, Worcester Pearmain, and Tydemans Late Orange. The first two of these were chosen as they are the most widely planted commercial varieties, whilst the third is a newer but increasingly important type. The three varieties give adequate pollination and a good succession of maturity, spreading the picking season and allowing a large proportion of the crop to be stored if necessary. A small collection of other varieties is also grown for observational experiments. The rootstock throughout was selected after consultation with other research organizations, and is M XVI.

An area of five acres of culinary apples was also planted in 1955. The main variety is Bramley, with pollinators of Grenadier and Edward VII. These varieties are common commercially and give a succession of picking. The rootstock used here is M II, and the planting distance twenty-four feet square.

The pear plantation covers eight acres, and the varieties used are Conference, Bristol Cross and Williams Bon Chretien. All are worked on Quince A stock, but the last two varieties are double worked to avoid incompatibilities between rootstock and scion. Planting distance is twenty feet square.

Maiden trees were planted throughout, and all the top fruit has been pruned to a delayed open centre form. Growth of the culinary apples and pears was rather less vigorous than desirable in the first two years after planting, but since has improved considerably. Dessert apples have grown vigorously since planting, and in the winter of 1958–59 pruning was deliberately light to encourage fruiting, and consequently in 1959–60 considerable thinning of growths had to be undertaken. The first light crop of fruit was taken from the top fruit in 1959. Hitherto all the orchard has been clean cultivated, but the dessert apples will be grassed down in 1960 using a Rhys Williams orchard seed mixture.

Since the soil is light and prone to drought, good establishment of the trees was essential before experimental differentials were applied. In view of this, uniform fertilizer and cultural treatment have been given to the major portion of the orchards, the trees being heavily mulched with straw to conserve moisture in the soil. This reserve area will be used for experiments in the future.

As establishment was likely to be difficult, two small experiments were laid down on dessert apples and pears to study establishment methods, whilst demonstrations of nutrient deficiencies were laid down on all three crops.

Blackcurrants. Three varieties were planted in 1955. The three varieties are selected to give a succession of fruiting, and are all widely grown types. Mendip Cross ripens first and is followed by Wellington XXX and Westwick Choice. The 'hedge' system of planting is adopted, bushes being spaced four feet six inches apart in rows nine feet apart. All bushes are mulched with straw except where experimental needs demand otherwise. After planting, bushes were cut to within an inch of the ground, and this severe cutting back was repeated twelve months later. This delayed cropping, the first crop being taken in 1958, but it resulted in very good growth of bushes, and the first crop amounted to thirteen and a half tons of fruit from five acres.

Practically the whole of the blackcurrant area is laid down to experiments, covering nutritional factors and weed control. The nitrogen, phosphate and potash requirements are under investigation, and both nitrogen and potash have increased yields, the Levington soil being well supplied with phosphate. Different organic and inorganic sources of nitrogen gave similar responses, whilst straw mulching improved growth and yields considerably. Simazine proved an effective weed killer amongst blackcurrants, but possible long-term build up of the weed killer in the soil, and its effect on growth and cropping, are still under investigation.

Strawberries. An acre of Royal Sovereign strawberries was planted in the spring of 1956. A pre-planting dressing of 30 tons per acre of farmyard manure was ploughed in, and plants were de-blossomed in the summer of 1956. Experiments on the nitrogen, phosphate and potash requirements, and nitrogen sources, were laid down, but no differential responses were noted. After three crops, the area was ploughed up in 1959.

A further acre of the same variety was planted in autumn 1956 and devoted to similar experiments. Again the plants were de-blossomed in the maiden year, and two crops have so far been taken from this area.

Non-nutritional experiments on strawberries have centred around the chemical control of runner development. On the variety Royal Sovereign a single application of 0·1 per cent maleic hydrazide effectively controlled runner formation without impairing vigour or reducing yield. This investigation has been extended on new plantings of strawberries. In 1959 half an acre of six different varieties was planted, and a further acre will be planted in the spring of 1960. The varieties used in this investigation are Royal Sovereign, Huxley Giant, Cambridge Vigour, Cambridge Favourite, Talisman and Redgauntlet; these represent the most widely grown commercial varieties.

Vegetable and Outdoor Flowers

Approximately twenty acres of land is available for vegetable research. Nutritional experiments on vegetables and flowers present a particular problem, since after the application of different fertilizer treatments for a short-term vegetable or flower crop considerable residual nutrient differentials may remain, and the land needs to be brought to a uniform nutritional level before further experiments can be laid down. This is done by putting the land down to ley for several years, the grass being cut and removed for fodder.

Since 1956 various subjects have been investigated in relation to vegetable and flower crops. Nutritional experiments on lettuce, carrots, cabbage and broccoli have been concerned with comparisons of nitrogen sources. Particular attention has been paid to ureaformaldehydes which so far have shown no great advantages over other sources. Aldrin incorporated in fertilizer gave a very satisfactory control of cabbage root fly, but experiments on carrot fly control were inconclusive due to low pest infestation.

Maleic hydrazide applied to the foliage of red beet and lettuce in an effort to inhibit bolting did not prevent the formation of the inflorescence, although elongation was prevented.

A special formulation of maleic hydrazide has also been found to control the growth of various hedges, especially privet. It will successfully retard the growth of privet for up to about three months from the time of application, thus very considerably reducing the need to cut the hedge.

Gibberellic acid was used on a wide range of flowers and vegetables, and many previously reported effects have been confirmed. On the whole, little or no benefit was gained from its use as there were usually undesirable side effects.

The systemic insecticide, Rogor, was investigated on flower and vegetable crops (and also on fruit). Besides giving good control of pests, Rogor was safe for use with edible crops provided there is a seven-day interval between treatment and harvest.

Trial Beds

A wide range of outdoor plants, commonly found in amateur gardens, is supplied by a unit set up in the winter of 1958/59, and these are used for general testing of products after detailed tests on a few species specially selected and grown for the purpose.

This area, two acres in extent, was ploughed out cocksfoot ley and was divided into four equal-sized strips, separated by wide paths. In these strips will be found most plants grown in the average garden as well as many that deserve greater popularity. The area has some two hundred and fifty different shrubs, one hundred and sixty different herbaceous plants, a sixty-five variety rose collection, and very large annual flower, dahlia and chrysanthemum collections which are planted annually. All the common vegetables and herbs and many popular fruit varieties are grown.

Glasshouse Crops

The glasshouse unit, covering half an acre, was erected in the winter 1955/56. There are nine commercial glasshouses connected on their northern end by a glasshouse corridor. Four of the houses are joined together in blocks; others are built separately for crop isolation. Between these latter houses are cold and heated frames used for plant raising.

The six vinery-type houses, one propagating house, and two cucumber houses are built in traditional style but incorporate several modern features. The light, already of high intensity in this area, is further improved in the houses by using glass twenty-four inches wide – thus reducing the number of roof bars.

The heating system is high-speed hot water through one and a quarter inch pipes designed to give the even heat essential for experimental purposes. House temperatures are thermostatically controlled through a system of motorized valves. The heating pipes are detachable for easy removal during winter routine operations.

HORTICULTURAL UNIT

An interesting feature is the direct steam line laid to each house for soil sterilization. This system was used for the first time during the winter 1959/60 when the soil in all five tomato houses, the carnation house and both cucumber houses was steam sterilized for the first time. To avoid soil transference from one experimental plot to another the single pipes fitted with spikes were used after the soil had first been dug. The system proved to be an efficient one.

Tomatoes. This is the largest glasshouse crop grown at Levington, occupying five glasshouses. The first experiments were started in the heated houses in 1957 after a cold crop had been taken in 1956.

Nutrient experimental work with tomatoes at Levington, as with most other crops, is carried out on a crop grown to the highest standards. To this end cultural techniques are adopted giving the plants in the early stages higher temperatures and humidity than are sometimes given in the industry. Careful training of the plants after they have reached the top of the wire is necessary to ensure fruit is picked within the correct plot, the method being to train the unstopped plants over the double planted row and down the opposite plant.

The variety Potentate is used for all experimental work in the glasshouses, this being the variety widely grown in the industry capable of producing heavy weight, though often poor quality – which is likely to be accentuated with adverse fertilizer treatment. Being a small-rooted variety it is also quickly responsive to fertilizers. It has been found necessary to apply large amounts of water due partly to the extremely open nature of the soil. A rate of thirty-five thousand gallons per acre per week was applied during part of the hot summer of 1959.

Mainly to increase the water-holding capacity of the soil, annual dressing of farmyard manure has been applied, and some improvement in the soil condition since 1956 is apparent.

Experimentation on tomatoes is with a standard size plot of twenty-four plants grown in a double row with the end plants treated as guard plants, yields of which are not included in experimental results. To avoid the risk of solid top dressing fertilizer being spread from one plot to another during watering, asbestos edging is erected. This edging is taken up at the end of each crop, sterilized, and replaced before planting.

In an experiment comparing varying rates and dilutions of liquid fertilizer with solid feeding no differences in total yield appeared in 1957 or 1958. This experiment is continuing.

A long-term experiment on tomatoes examines various rates and combinations of phosphate base dressing and nitrogen, phosphate and potash top dressings. In 1958, as 1957, no improvements in yield or quality were obtained above the minimum nutrient rate applied. Few clear cut differences were expected on new glasshouse soils, and the experiment will continue to examine long-term nutrient build-up.

An experiment compared a number of organic and inorganic sources of nitrogen applied as top dressings at equivalent nitrogen rates. In this short-term investigation on a new tomato soil, no substantial differences were observed. The experiment has been concluded after three years, and the two houses which it occupied will in future be used for an extension of the liquid feeding programme.

The crop weight throughout all the glasshouses fell from eighty tons per acre in 1957 to seventy tons per acre in 1958 to fifty-six tons per acre in 1959. As crop vigour was not satisfactory throughout the latter season it was decided to steam sterilize the soil during the winter 1959/60.

Other experiments on tomatoes have been carried out on pot grown plants and have included an examination of plants grown by the ring culture system, gibberellic acid and its effect on fruiting, and the effect on plants of gypsum induced low pC readings.

Carnations. The first carnation crop at Levington was planted in late February, 1957; cutting started in July, 1957, and the crop was removed at the end of 1959. The plants cropped at an average of forty-two blooms per plant during this period. Several different varieties were grown, an interesting feature being the use of a row of a different coloured guard variety to separate the plots. This assisted speedy and accurate cutting and recording.

In an experiment examining the effect of various nitrogen and potash rates and nitrogen sources, no significant results were obtained.

Comparing liquid feeding with solid feeding of carnations, L.5 was as efficient as G.H.5 as a top dressing. It appeared, for the first eighteen months of cutting, that a liquid feed of medium concentration fed frequently gave slightly more blooms than any other treatment.

Both experiments are to be repeated in a modified form on the new crop of carnations planted in February 1960. To prevent root growth from one plot to another, which may have been influencing previous experimental results, permanent asbestos sheets have been placed between the plots to a depth of eighteen inches.

Cucumbers. This crop has been an outstanding one at Levington for the three years 1957, 1958 and 1959. In 1958 a total crop yield of ten tons one hundredweight was obtained from four hundred feet of bed, or two and three-quarter flats per foot, giving a yield at a rate of eight tons eighteen hundredweight per acre. This result was obtained from an end of February planting, and the plants continued fruiting until the end of September.

Only one experiment is carried out on this crop, and it has studied the effect of substituting inorganic for organic nitrogen in the base and top dressings. Results so far have shown the one to be as effective as the other but it should be noted that for the past three years new beds have been used for experimentation. In future, the old bed will be retained for use after steaming and this change in technique, common in commercial practice, may shed light on the relative values of organic and inorganic fertilizers. As with the carnations, divisions have been erected to limit the spread of roots in the bed and base soil.

All tomatoes, carnations and cucumbers are graded for size and quality before being recorded and marketed. Experimental results are based on these factors as well as weight.

Corridor Plants. In the corridor connecting the glasshouses, as well as in the propagating house for a large part of the year, decorative plants provide a wide range of material on which products may be tested.

Experimental Turf

In 1956 an area of one and a half acres to the north of the glasshouses was established for fine turf experiments. Initially half of this area was sown with a seed mixture consisting of fescue and browntop, and half with a mixture of S.23 perennial ryegrass and H.I short rotation ryegrass. The ryegrass section was replaced by a fescue-browntop sward in 1957.

Since 1956 the area devoted to turf experiments has been gradually increased. In 1957 two and a half acres were added. Approximately three-quarters of an acre of this was sown with a seed mixture containing wild white clover so that weed control experiments could be conducted here on a sward which contained a uniform infestation of at least one common turf weed. Clover was chosen as being a relatively resistant turf weed, and as such one which is useful as an indicator plant when the potentialities of different herbicides are being considered. This year, an area is to be sown

with a seed mixture containing other common turf weeds so that a sward with a uniform infestation of these will be available at Levington for future weed control experiments. The remainder of the experimental turf which was established in 1957 was sown with seed mixtures containing fescue and browntop, and in addition some crested dog's tail was included on one area.

Finally, an acre of turf for experimental purposes was sown in the spring of 1959. This area which was sown with a seed mixture containing fescue, browntop, crested dog's tail and rough-stalked meadow grass completes the five acres at present devoted to turf experiments.

Turf experiments consist of both short-term investigations and long-term projects which are designed to improve existing turf fertilizers and weed killers and to formulate new materials for the treatment of all types of turf – both sportsgrounds and ornamental lawns – which will be more efficient and less costly than existing treatments.

The turf experimental programme covers three main subjects, namely, nutrition, weed control and moss control. In addition, experiments have also been conducted on the growth inhibition of turf grasses with maleic hydrazide.

Nutrition. The main aspects of turf nutrition under investigation are the effects of sources and rates of nitrogen, phosphate and potash on sward growth and composition. A long-term investigation to study changes in botanical composition over a period of several years is in progress, from which information will be obtained on the most suitable materials to encourage the fine leaved, desirable turf grasses whilst discouraging weed growth. The comparison of spring and autumn applications of phosphate and potash is also being made.

The value of organic nitrogen sources in turf fertilizers is investigated. The nitrogen in these sources is more slowly available and it is possible that with the right materials, the response to a nitrogen turf fertilizer can be extended.

The conditions under which scorch is most likely to occur with liquid fertilizers have been defined, and different nutrients will be examined at various rates under these conditions to obtain information on the concentrations that do not cause scorch.

Weed Control. As mentioned above, an area was shown in 1957 with a grass seed mixture containing a small percentage of wild white clover which is a very common turf weed, and as such it was considered to be a useful weed to use as an indicator

plant with which to examine the potentialities of different herbicides. Since 1957 experiments have been conducted on this sward. Various herbicides in aqueous solution and in combination with powdered and liquid fertilizers have been examined and some treatments have given a very good and prolonged clover control.

In addition to the weed control work at Levington, many of the experiments which were initially put down at Levington have been repeated elsewhere on swards containing weeds other than clover to examine the effect of the herbicides on as many different weeds as possible. In this work a good control of plantain, daisy and pearlwort has been obtained.

In these weed-control investigations, the use of a logarithmic sprayer has enabled very many concentrations, rates of application and combinations of herbicides to be examined.

Moss Control. Mosses can be classified into two groups. Pleurocarpous and Acrocarpous mosses. Of these, Pleurocarpous forms feature most prominently in turf, but Acrocarpous forms are also common – especially on intensively managed swards which are mown very keenly, such as bowling and golf greens. Since 1957 experiments have been conducted with various chemicals on swards containing both types of moss although, due primarily to its availability, the emphasis has been on Pleurocarpous forms.

The results of the moss control experiments have indicated that Lawn Sand containing sulphate of ammonia, sulphate of iron and a small percentage of calomel give both the most rapid and prolonged moss control, but that Lawn Sand without calomel will give a good initial control which could be sustained with correct management. It is questionable whether the extra expense involved with the use of calomel is justifiable.

Growth Inhibition. Since 1956 several experiments have been conducted with maleic hydrazide to examine its value in the inhibition of turf grasses. This work was carried out on ryegrass swards consisting of S.23 perennial ryegrass and H.I. short-rotation ryegrass, and on fine turf containing fescue, browntop, rough-stalked meadow grass and crested dog's tail. In both cases a good growth inhibition was obtained but the grass was discoloured. The discoloration was persistent and unacceptable. For this reason maleic hydrazide is considered unsuitable for the inhibition of turf grasses, at this stage of development.

Turf Grasses. During 1958 and 1959 a turf nursery was established from which turf is used for demonstration purposes. This contains a section of sea marsh turf and an area which was sown with a seed mixture containing fescue, browntop, rough-stalked meadow grass and crested dog's tail.

In addition, small plots are shortly to be established of individual species using twenty different grasses which are commonly found in turf.

Ornamental Lawns

In addition to the turf for experimental purposes approximately three acres of ornamental lawns have been established at the Research Station since 1956. The two main front lawns were sown using a seed mixture containing fescue and browntop, and other lawns have since been sown using the same seed mixture. All the lawns were sown after extensive blade grading and cultivation of the top soil. In spite of the very light soil and the low rainfall which is a feature of this part of the country, the lawns developed satisfactorily under normal management. Management consists of regular mowing – twice weekly when growth is vigorous – regular annual fertilizer treatments and occasional wire raking and spiking.

Above: Nitrogen nutrition is studied in two cucumber glasshouses.

Below: The five glasshouses growing tomatoes cover experiments on rates of fertilizer application, sources of nitrogen, and liquid fertilizers.

Above: The Grassland Research Section is centred on North Wyke. The Carolean manor house has been converted internally for staff accommodation, laboratories and offices.

Below: Nearly four hundred acres of a typical Devon grassland farm are available for investigations on the production of herbage and its utilization by livestock.

North Wyke Experimental Station

North Wyke Experimental Station supplies the facilities for the Grassland Research Section of the Levington Soil Science Department.

The estate was purchased in the autumn of 1955 to provide facilities for grassland research in a typical grassland area. It is about three miles from North Tawton and seven from Okehampton, lying between 400 and 600 feet above sea level. The soil is predominantly culm measure clay and, with an annual rainfall of approximately 35 inches, is in complete contrast to the light soil and low rainfall conditions at Levington.

The Manor House has been modified internally to provide residences for the officer-in-charge and the farm manager, a conference room, library, offices, laboratories and a canteen. Some of the existing farm buildings have been converted to provide an oven room and a cold room as well as housing for experimental animals. Facilities for the latter are to be extended. Four new cottages have also been built.

The Manor House dates from the fourteenth century and has been much altered and restored through the ages, notably in Tudor and Stuart times. It was owned by the Wykes or Weekes family for centuries. The Royal Arms of the early Tudor period, carved in stone, are inset above the Gate House to commemorate visits by the Royal Princes Arthur and Henry, sons of Henry VII. Extensive restorations to the house were carried out in 1895. It is included in the list of Buildings of Special Architectural and Historical Interest and is noted for its beautiful ashlar work.

Grassland Research

The Section is investigating the production and utilization of herbage from grazed swards as it is affected by nitrogen, phosphate and potash applications. Both yield and quality of herbage are considered with particular emphasis on the contribution from clover.

The research programme can be considered in three aspects. Firstly experimental technique, which is particularly complicated in experiments involving animals. Secondly, production experiments in which results are obtained from harvested samples of herbage. And finally, experiments where the results are measured either in terms of animal production of meat or milk, or by digestibility trials with animals.

Technique. As a first step, a series of experiments has been initiated to clarify the experimental techniques that will be used in grassland experimentation at North Wyke. In such a complex subject, the use of the correct techniques is essential if comparable and valid methods of assessment are to be used for investigations into different aspects of the main problems. These techniques may have to be modified as more information on them is obtained.

The technique studies at present being undertaken include investigations on:

(a) Methods of maintaining pure stands of grass and clover.
(b) The effects of 2,4,5-T when used as an eradicant for clover from a grass sward.
(c) The suitability of a range of sampling implements under a variety of conditions.
(d) The errors associated with short-period grazing and feeding experiments.
(e) The use of simulated grazing techniques.
(f) The use of lactating goats as substitutes for cows.

The last of these investigations is of particular interest, in that it offers economy of plot size and feeding stuffs combined with experimental flexibility, but as yet little is known of the relative performance of goats and cows on different foods and more investigation is required before the goat can be accepted as a valid standard of measurement even for special purposes. Milking goats and dairy cows are being used to investigate short-period changeover techniques under zero grazing and indoor feeding conditions, and data are being collected to compare the performance of goats and cows.

The use of simulated grazing techniques may help to overcome the difficulties involved in employing the animal in field experiments and the Section is developing ideas published by other workers, as this type of technique may be increasingly used in the future. In 1958, a small experiment was started comparing herbage productivity

under sheep grazing conditions, the main treatment comparisons being cutting with (a) return of clippings, (b) return of dung and urine, and (c) re return.

Herbage Production. The second aspect of the programme consists of experiments in which the herbage is cut and no attempt is made to graze or to simulate grazing. Such experiments are conveniently and advantageously conducted at sites on farms throughout Great Britain where sources of nitrogen, phosphate and potash, as well as times and rates of application, are investigated. The interpretation of results from experiments carried out in this way is limited by the particular conditions of harvesting with a cutting machine.

At North Wyke, this method is being used to study the differential response to fertilizers of three grass species and to investigate the effect of placement of fertilizers into an established grass sward.

The technique is also of particular value in fundamental studies on the contribution of nitrogen from clover in a mixed sward. An experiment in which there are two different cutting times, five rates of nitrogen application and two sward types (grass and grass with clover) has been started with the object of elucidating some of the problems of nitrogen transfer from clover to grass at different levels of nitrogen fertilization and different frequencies of defoliation.

Animal Utilization. The third aspect of the programme concerns experiments involving the grazing animal.

One investigation examines the phosphate and potash requirements of a pasture grazed by dairy cows, there being very little experimental evidence on the responses to these nutrients under grazing conditions.

Studies are also being carried out preparatory to a series of investigations on the levels and frequency of application of phosphate and potash required for maximum herbage production at selected levels of nitrogen usage.

Investigations into the nitrogen contribution from clover to the mixed sward must also include the grazing animal as much of the nitrogen transfer may occur through the animal. Initially, the differential effects of nitrogen rates and times of application on grass and grass/clover swards are being examined and the investigation will be extended in 1961 to consider the effect of phosphate and the nitrogen/phosphate interaction. These investigations involve the use of grazing sheep.

Herbage quality as affected by fertilizer treatment will receive great emphasis in future research, the effects of treatment on herbage digestibility and palatability in relation to animal productivity being examined.

Animal health investigation will not normally form part of the research programme. An exception is the study of the relationship between fertilizer practice (for example, rates of nitrogen and potash application), sward composition and hypomagnesaemia. At Levington, in the last few years, the effect of adding magnesia to the soil has been studied both in herbage mineral content and in the blood serum levels of dairy cows grazing on treated herbage.

It is anticipated that the Grassland Research Section will be able to examine the conclusions derived from their grassland projects, on farms other than North Wyke and Levington. A wide range of grassland soil types and climatic conditions will be covered so that the research results will be evaluated under general rather than particular conditions.

Provincial Field Experiments. The Section is also responsible for carrying out that part of the provincial field experiment programme located in the South Western counties (Area 5) and some of these experiments are sited at North Wyke itself.

Experimental Areas

Experiments may be sited on any suitable field on the farm but there are certain fields specifically reserved for certain types of experiment as indicated below.

Long-Term – Fields 4, 35, 36. On these fields, long-term experiments will be down for an indefinite period.

Low-Phosphate Status Grassland – Fields 30, 31, 52, 53. Grassland with a low-phosphate status is produced in these fields for certain types of experiment, particularly where the value of different sources of phosphate is being assessed.

Low-nutrient Arable Area – Field 22. Twenty acres are farmed in a rotation with controlled fertilizer usage to provide three acres per annum for arable crop nutritional experiments. (Compare Levington Farms, Area 11, p. 18).

Drainage – Field 37. Initially, six acres of land have been set aside for drainage experiments. Drainage of culm measure clay is of considerable interest and the percolation of water is under examination. For this purpose the field has been thoroughly drained by a uniform system of tile drains and from 1961 the land will be used to study the effect of various treatments on time and rate of drainage-water flow.

Demonstration Area – Field 20. Although the farm is used for research and experimentation, a small area of land has been reserved for a manurial reference trial and for grass species reference plots.

The manurial reference trial demonstrates crop growth differences in the presence and absence of the major plant nutrients. A rotation adapted to local needs is employed and the effects are demonstrated on potatoes, cereals and grass.

North Wyke Farm

The prime requirement of the farm is to provide facilities for grassland research. In 1945 a dairy herd had been introduced and considerable modifications made to the buildings. This herd has been retained and sheep introduced as necessary adjuncts to grassland research. The cropping has been designed to clean the land and improve or reseed all the older grass fields. A considerable amount of reclamation of rough grazing and scrubland has been, and will be, undertaken and hedges and ditches have been removed or replaced where necessary. Much of the woodland acts as drainage areas to the surrounding agricultural land.

A new shippon has been built, and the cowshed that existed has been converted to calf houses and loose boxes. Additional accommodation for implements has been erected and better facilities for ensiling, storing dung and assembling animals have been provided. Mains water supply has been connected and all fields are watered from this source. The acreage changes which have occurred since the farm was purchased are summarized as follows:

	1955	1957	1959	1960
Agricultural land	193	231	257	262
Rough grazings	55	26	—	—
Scrub and woodland	130	121	121	116
Roads and Buildings	8	8	8	8
	386	386	386	386

Livestock. A pedigree herd of attested Ayrshires was taken over with the farm in 1955 and is maintained to provide cattle for experimental use and produce milk commercially. It is intended to milk fifty cows all year round and followers are reared to provide all replacements. The present herd numbers:

Cows	60
Down calving heifers	20
Yearling heifers	20
Heifer calves	10–15
Bull	1

All first calf heifers and some of the dairy herd are served with a beef bull and their calves are sold at a few weeks old. The remainder of the dairy herd is mated with an Ayrshire bull to provide herd replacements. The maximum possible use is made of grazing and home-grown conserved foods, supplemented as necessary by purchased concentrates.

36
LONG TERM AREA
37
DRAINAGE AREA
35
23
57
LOW NUTRIENT ARABLE AREA
22
55
42
34
33
58
21
9
65
1
15
64
50
32
59
20A
8
11
20B
DEMON-STRATION AREA
16
41
20
17
12
51
66
6
13
63
LONG TERM AREA
5
2
54
40
4
3
52
60
68
53
30
62
LOW PHOSPHATE AREA
61
31
N
Woodland and Scrub

Cropping and Fertilizers 1960

Field No.	History	Crop	Fertilizer Applications 1st Type	1st Rate (cwt/acre)	Subsequent Type	Subsequent Rate (cwt/a
1	Seeded 1959 after cereals	S.22	41	4	S/A	6
2	Seeded 1959 after kale	T/MF/S.100	42	4	S/A	3
3	Seeded 1958 after cereals	T/MF/S.100	42	4	S/A	4
4	Reseeded part 1958, part 1959	T/MF/S.100	EF	Various		
5	Seeded 1957 after cereals	T/MF/S.100; T/R/S.100	41	4	S/A	4
6	Seeded 1959 after cereals	S.22	41	4	S/A	6
8	Old ley	Winter wheat	45	4	S/A	4
9	Seeded 1960 after rape	T/R/S.100	45; BS	4; 5	S/A	2
11	Old ley	Rape and Italian	42	4		
12	Seeded 1960 after rape	T/R/S.100	45; BS	4; 5	S/A	2
13	Reseeded 1959 after old ley	T/MF/S.100	41	4	S/A	6
15	Seeded 1957 after fallow	T/R/S.100	42	4	S/A	2
16	Reseeded 1959 after permanent pasture	T/R/S.100	42	4	S/A	2
17	Reseeded 1960 after Italian	T/R/S.100	45; BS	3; 5	S/A	2
20	Permanent pasture	Permanent pasture		Demonstrations		
20A	Old ley	Winter oats	47	3	S/A	2
20B	Permanent pasture	Permanent pasture	42	4	S/A	2
21	S.22 after old ley	Kale	42	4	S/A	2
22	Reseeded 1951 after old ley	Arable crops; long ley	EF; S/A	Various; 4		
23	Seeded 1960 after arable crops	T/R/S.100	45; BS	3; 5	S/A	2
30	4-year ley	Swedes	EF	Various		
31	Seeded 1957 after rape	R/S.100	N/P	4	S/A	2
32	Seeded 1959 after rape	T/S.100	41	4	S/A	2
33	Seeded 1959 after arable silage	T/R/S.100	41	4	S/A	6
34	Seeded 1959 after rape	Italian	45; BS	4; 5	S/A	2
35	Reseeded 1958 after old ley	T/R/S.100	EF	Various		
36	Reseeded 1958 after old ley	T/R	EF	Various		
37	Reseeded 1959 after old pasture	Italian	S/A	3		
40	Seeded 1958 after rape	T/R/S.100	45; BS	2; 5	S/A	2
41	Reseeded 1959 after old ley	T/R/S.100	41	4	S/A	4
42	Seeded 1948	Permanent pasture	S/A	4		
52	Seeded 1960 after lupins	Rape and Italian	42	5		
53	Seeded 1959 after Italian	Cocksfoot/S.100	N/P	4	S/A	2
54	Scrub	Being reclaimed		—		
64	Seeded 1959 after reclamation	Rape and Italian	S/A	2		

Abbreviations: T Timothy, MF Meadow Fescue, R Ryegrass, EF Experimental fertilizers, S/A sulphate of ammonia (21% N), N/P nitrate of potash (15% N, 10% K_2O) BS basic slag (16% P_2O_5).

Compound Fertilizer Analyses:	N	P_2O_5	K_2O
Fisons 41	10	10	18
Fisons 42	16	9	9
Fisons 45	6	15	15
Fisons 47	0	14	28

A small flock of Scotch half-bred ewes was purchased in 1957 and these are mated with a Suffolk ram to lamb in March and April. Most of the lambs are fattened on grass and the rest are finished on rape and ryegrass except for a small number of wether lambs that are kept through the winter for use in experiments in the following year.

Cropping. That part of the farm which is not immediately required for experimental use is cropped on commercial lines, future experimental requirements being taken into consideration. Basically, the rotation is a system of long leys which are ploughed when necessary and put through a rotation of either rape and ryegrass or kale followed by S.22 ryegrass, before being sown out to a long ley again. It is intended that there will be at least ten acres of kale and ten acres of newly sown ryegrass every year in addition to an undefined acreage of rape and ryegrass.

The two long-ley seeds mixtures that are in use are:

4 lb. Timothy S.48	6 lb. Timothy S.48
4 lb. Timothy S.51	5 lb. Meadow Fescue S.53
10 lb. Perennial ryegrass S.24	5 lb. Meadow Fescue S.215
1 lb. Montgomery LF Red	2 lb. White Clover N.Z. Cert
1 lb. White clover N.Z. Cert	—— Mother
—— Mother	18 lb.
20 lb.	

In the development years, both Cocksfoot/White Clover and Timothy/White Clover mixtures have been used on suitable fields.

Compound fertilizer use on these leys is in accordance with normal recommended levels and the quantity of nitrogen used varies with season and sward. The use of high nitrogen levels is normally limited to the short rotation ryegrass swards where up to 200 lb. per acre of nitrogen (equivalent to 10 cwt. sulphate of ammonia) may be applied, in addition to phosphate and potash.

Results of Agronomic Experiments—1958

In 1958 many subjects of investigation in Agriculture, Horticulture and Pot Trials were continued from 1957, and a number of new subjects were introduced. The statements on results are restricted in the main to data obtained during one year and therefore have limited value.

Results of experiments should be viewed in the light of the weather conditions in 1958. In England and Wales the weather was generally dull and wet but in Scotland rainfall was below average and there was about average sunshine. A very cold March which delayed most crops was followed by a sequence of five unusually wet months (May–September). Winter cereals were slow to make growth in spring while spring cereal sowing was delayed. The crops least affected by the adverse conditions in spring and early summer were grass, sugarbeet, potatoes and other root crops. Prolonged periods of rain in July and August damaged all crops and potato blight, take-all and other crop diseases were prevalent. Harvesting conditions were poor and cereal samples were generally inferior. Barley crops were the worst affected due to lodging and secondary growth. On the whole these effects were less serious in eastern England and in particular some excellent crops of sugarbeet were obtained.

Agricultural Results

Twenty-seven experiments at Levington and in the provinces on winter wheat, barley, grass, sugarbeet and kale compared responses to a number of nitrogen sources including ammonium nitrate, ammonium sulphate, calcium nitrate, urea, mono-ammonium and diammonium phosphate, and calcium ammonium nitrate. No large differences were detected except in the case of urea which in four grass experiments gave lower dry matter and crude protein yields than ammonium sulphate and ammonium nitrate. One experiment in north-east Scotland confirmed the lack of response in spring grass to autumn applied nitrogen.

Kale responded up to 240 lb/acre of nitrogen at three sites in western England, the size of response being in each case much above that usually found. No advantage was gained from splitting the application between seedbed and top dressings, and in some cases a split application led to reduced yield.

In six experiments on typical barley soils application of half or more of the nitrogen in June gave a markedly inferior yield of grain at some centres compared with earlier applications, thus confirming previous results. Such losses more than offset the small increases in crude protein content.

A North Wyke experiment examined the influence of frequency of cutting on fertilizer nitrogen recovery in grass at different levels of applied nitrogen. Results support the claim that grasses give a linear response in nitrogen yield to applied nitrogen even at the high levels where dry matter responses fall off. Total dry matter yields for the season were increased by cutting at more advanced stages of growth but the effects on nitrogen yield were not clear.

As in 1957 phosphate top-dressing of swedes and oats gave responses which were reduced compared with seedbed application but sometimes worthwhile compared with no phosphate application.

The series of annual experiments on typical soil types throughout the country examining four rates each of nitrogen, phosphate and potash in all combinations was continued with ten sites on potatoes. Nitrogen increased yield at nine centres, phosphate at eight and potash at five.

The effects of sulphate and muriate of potash on yield and quality of potatoes were compared at six centres. Muriate of potash consistently gave a higher yield of ware and lower yield of seed relative to sulphate but, in general, total yield was similar for the two sources. High rates of potash reduced tuber dry matter at three sites and at two of these sulphate of potash gave a slightly higher dry matter than muriate. No other marked quality differences were detected.

Experiments examining the effect of fertilizer and magnesium applications on the chemical composition of grassland herbage, with reference to hypomagnesaemia have continued. Results have shown that clover has a much higher magnesium level than grass, and this difference is most marked in April and May when the magnesium content of grass is falling. Nitrogen and potassium applications at high rates raise herbage potash levels and decrease the magnesium content of mixed herbage. Magnesium applied at rates up to 45 lb/acre MgO has little effect on herbage composition.

Magnesium and trace elements applied to barley as foliar spray at ear emergence on three typical soils had no beneficial effect and tended to reduce yield, probably because of foliar scorch. 30 lb/acre of nitrogen (in addition to normal fertilizer treatment) as solid or foliar spray raised grain protein content slightly in one case only and had no beneficial effect on yield at any centre. On two further sites not known to be deficient in trace elements the application as foliar spray of iron, manganese, boron, copper, zinc and molybdenum had no measurable effect on yield of oats.

The effects of gibberellic acid were examined in various contexts – the rate of bulking of early potatoes, the breaking of tuber dormancy in potatoes, seed production of sugarbeet and kale, and herbage production of grass and lucerne. In general, results were not encouraging.

Left: pH determinations of the soil in pots can be made *in situ* with portable equipment.

Below: Sub-irrigation from a watered sand-bed as well as the standard Mitscherlich method are used in pot trials. Increased illumination is supplied in the winter.

Above: Before field experiments are laid down, over 5,000 plots at Levington must be marked out accurately by Field Experimental Officers and Recorders.

Below: Yield measurements from harvested plots are made in the field and samples are taken for quality determinations in the laboratories.

Combine drilling at the high rates of $5\frac{1}{2}$ cwt/acre of Fisons 31 and $5\frac{1}{4}$ cwt/acre of Fisons 32 and 39 compounds had no detrimental effect on brairding or yield of barley in four experiments on light land in East Suffolk under conditions likely to be conducive to damage.

The examination of the use of herbicides in fertilizers for the control of grassland weeds continued. Experiments have shown that an important characteristic of an efficient carrier is fine particle size.

In three experiments on wheat bulb fly infested sites Aldrin combine drilled in fertilizer at 1·2 lb/acre and as dust at 1·6 lb/acre were equally effective control measures. At two other infested sites Aldrin combine drilled in fertilizer checked the attack, 0·3 lb/acre being sufficient in one case and up to 0·75 lb/acre being effective in the other.

A preliminary investigation at Levington showed that spraying with Phortox to eliminate clover from grass/clover swards would not be a satisfactory technique for obtaining a pure grass sward for nitrogen nutrition studies, at least in the same year and where clover is established, because of residual nitrogen contributions of the dead clover roots.

At North Wyke two projects were initiated to investigate the use of changeover designs with cows involving grazing periods of only one week. Another changeover design employed milking goats in stalls. In all three experiments variation in milk yield was satisfactorily controlled by the changeover technique and in one case significant differences in milk yield due to differences in the type of sward were demonstrated.

Horticultural Results

These results are discussed in the section on the Horticultural Unit.

Pot Trial Results

The Pot Trials Unit was used extensively by the fundamental research sections and their results are commented on elsewhere. In addition work continued from 1957 on the long-term effects of ureaformaldehyde and on nitrophosphates, and further subjects were introduced. These included a number of technique experiments, the importance of particle size of basic slag and the effects of gibberellic acid on a range of plants.

An experiment continued from 1957 indicated that ureaformaldehydes in general, although inferior to inorganic nitrogen in the short term, were releasing nitrogen at a greater rate during the second season of growth when they gave comparable results to standard organic sources.

Responses to nitrophosphates were related to their water-soluble P_2O_5 content, thus confirming the findings of the 1957 series.

Gibberellic acid was examined from various aspects including the breaking of dormancy of apples and flowers, the stem elongation of flax and the early emergence of potato sprouts. Only the latter effect was obtained but the yield was unaffected. The domancy of a number of weed seeds was effectively broken.

A technique experiment showed that the movement of soluble nutrients in the sand-bed was negligible. In a further experiment the optimum rates of nitrogen, phosphate and potash on barley were obtained.

Field and Pot Experiments—1960

Field and pot experiments, an essential part of the fundamental and applied studies, link laboratory investigations with farm and horticultural practice. The research farms, the horticultural unit, and the provincial service throughout Great Britain are available for carrying out experiments. In this way, research projects organized from Levington can be examined in all phases of the soils and climate which constitute British farming and horticulture. This season more than sixteen thousand plots in agricultural and horticultural experiments are being laid down, over half being provincial, and the Pot Trials Unit at Levington has an extensive complementary programme.

Agricultural Experiments

The 1960 agricultural programme consists of 513 experiments comprising 13,984 plots. This programme embraces both general agriculture and specialized grassland, many of the experiments being continued from previous years.

Subjects of investigation in general agriculture include (a) sources of nitrogen, including anhydrous ammonia, for grassland and arable crops, (b) the effect of phosphate on cereal development, (c) nitrophosphates, (d) the long-term phosphate requirement of soils initially well supplied, (e) phosphate and potash requirements of crops when high levels of nitrogen are used over a period of years, (f) time of application of phosphate and potash to wheat, (g) effect of combine drilling high rates of nitrogen and potash with cereals, (h) the nitrogen, phosphate and potash requirements of early and maincrop potatoes, (i) magnesium for arable crop production, (j) plant nutrition in relation to the incidence of potato blight and cereal take-all, (k) fertilizers incorporating insecticides for the control of wireworm and wheat bulb fly, and incorporating herbicides for weed control, (l) field experimental technique.

In the specialized grassland studies emphasis is given to (m) the contribution of clover to the mixed sward, (n) time of application and types of basic slag for grassland, (o) the improvement of marginal grassland by application of lime, slag and

trace elements, (p) the effects on the magnesium content of spring grass of small annual applications of magnesium compounds, (q) the effect of small and large applications of magnesium to the herbage on the blood serum magnesium levels of dairy cattle in spring, (r) the effects of various levels of phosphate and potash on the production of a mixed sward grazed by dairy cattle, (s) grass sampling and animal measurement techniques.

At Levington this year, annual and long-term experiments occupy about forty acres; here the crops under investigation include grass, autumn and spring cereals, potatoes, sugarbeet, mustard, kale and lucerne.

Key to Locations

L	Levington Research Station, Ipswich, Suffolk
W	North Wyke Experimental Station, North Tawton, Devon
1	Perth, North-East and South-East Scotland
2	Carlisle, North of England and South-West Scotland
3	Chester, West Midlands, North Wales and Lancashire
4	Bristol, South Wales, South Midlands and Southern Counties
5	South-Western counties
6	Lincoln, East Midlands and Yorkshire
7	East Anglian and South-Eastern counties

Code No.	Title	Crop	Subject under investigation	Location
GENERAL AGRICULTURE				
1.1/1	N source and time	Winter wheat	Nitrogenous fertilizer for autumn application	L, 3, 4, 7
1.1/2	N source, top dressing	Winter wheat	Nitrogenous fertilizers as spring top dressing	1, 2, 3, 4
1.1/3	N source, seedbed	Barley	Nitrogenous fertilizers for seedbed application	3, 5, 6
1.1/4	N source, rate and time	Grass	Time of application in relation to spring growth	3, 5, 7
1.1/5	N source, seedbed	Sugarbeet	Nitrogenous fertilizers for seedbed application	L, 4, 6, 7
1.1/6	N source, top dressing	Grass	Various nitrogenous fertilizers for intensive use on grassland	3, 4, 6, 7
1.1/9	N source, top dressing	Grass	Various nitrogenous fertilizers	2, 3, 4, 6, 7
1.1/14	N source	Potato	Nitrogenous fertilizers for potatoes	L, 1, 3, 4, 5, 6, 7
1.2/2	P rate and time	Lucerne	Rate and time of application of phosphate to established lucerne	7
1.2/3	P source, nitro-phosphates	Potato or Brassica	Various proportions of water soluble phosphate, residual effects of experiments conducted in 1959	L, 1, 2, 5

Code No.	Title	Crop	Subject under investigation	Location
1.2/4	P source, nitrophosphates	(a) Potato (b) Swede	Granular nitrophosphates containing various forms of phosphate	1, 2, 3, 4, 6 1, 2, 3, 4
1.2/5	P source, nitrophosphates	Swede	Residual effects of nitrophosphates applied in 1959	W
1.2/5	P source, nitrophosphates	(a) Spring wheat (b) Grass	To measure in 1961 the residual effects of nitrophosphates applied in 1960	L W, 2
1.2/9	P rate and method, crop development	Winter wheat	Phosphate rate and method of application	L
1.2/10	P rate and source, crop development	Spring cereal	Crop development and final yield as influenced by phosphate application	1, 2, 3, 4, 5, 6, 7
1.2/11	P rate, source and method, crop development	Spring cereal	Crop development and final yield as influenced by phosphate and method of application	1, 3, 5, 7,
1.2/12	Superphosphate components	Sweet lupin	Effect of the various constituents of superphosphate	W
1.3/2	K rate and time	Lucerne	Rate and time of potash application to established lucerne	7
1.6/1	PK time	Winter wheat	Time of application of phosphate and potash	4, 6, 7
1.7/1	NPK rate	Potato	Nitrogen, phosphate and potash rates in relation to yield, disease control, potato quality and soil analyses	1, 3, 5, 7
1.7/2	NPK rate	Early potato	Nitrogen, phosphate and potash rates for early potatoes	2
1.7/3	NPK rate, bulking	Early potato	Nitrogen, phosphate and potash rates in relation to rate of bulking	L
2.2/1	Mg rate	Mangold	The value of applied magnesium	2
2.2/2	NKMg rate	(a) Winter oat (b) Spring cereal	Magnesium deficiency in relation to nitrogen and potash rates	7 1, 2, 3, 4, 6
2.2/3	KMg rate and method	Spring oat	Methods of magnesium application in relation to potash rates and method of application	L
2.2/4	KMg rate	(a) Potato (b) Sugarbeet	Magnesium deficiency in relation to potash rates	1, 3, 4, 5, 7 L, 1, 3, 6, 7
2.2/9	Mg rate	Rotation	Additive effect of magnesium applications throughout a rotation	1
2.5/2	B source	Swede	Availability of boron from various sources when incorporated in fertilizer	1, 5
2.5/3	B rate	Lucerne	Use of boron on poor stands of lucerne	7
2.12/1	Granule size, phosphatic fertilizer	Swede	Granule size in relation to crop response to phosphate	1, 2, 3, 4
2.13/1	Compound fertilizer placement	Spring cereal	Combine drilling high rates of fertilizer under a wide range of conditions	1, 2, 3, 4, 5, 6, 7
2.13/2	'47' rate, placement	Winter wheat	Combine drilling high rates of potash in a PK compound	L, 1, 2, 3, 4, 5, 6, 7

Code No.	Title	Crop	Subject under investigation	Locations
2.13/3	N rate, source and method	Barley	Rate and source of nitrogen when combine drilled	L, 7
2.13/4	K rate, source and method	Barley	Rate and source of potash when drilled	L, 7
2.13/5	NK rate, placement	Barley	Additive effect of rate of nitrogen and potash when combine drilled	L, 7
2.13/6	P time and method	Winter wheat	Time and method of application of phosphate	L
2.13/8	Compound fertilizer placement	Pea	Combine drilling of fertilizer for peas in 7-in. rows	L, 6, 7
2.13/9	Compound fertilizer placement	Kale	Combine drilling of fertilizer	L
2.14/1	NPK exhaustion	Potato	Reponse to these nutrients after successive years of nitrogenous fertilization in rotations	L
2.19/1	Biuret toxicity	Barley	Toxicity from urea of various biuret contents	2, 7
2.19/2	Concentrated fertilizer	(a) Barley (b) Spring wheat	Combine drilling of certain concentrated fertilizers	L
2.19/3	Concentrated fertilizer	Pea	Combine drilling of certain concentrated fertilizers	L
2.19/4	Concentrated fertilizer	Grass	Use of certain concentrated fertilizers for top dressing	L
2.20/1	N rate and time, anhydrous ammonia	Kale	Residual effects of anhydrous ammonia applied to kale in 1959	L
2.20/1	Anhydrous ammonia	Kale	Rate and time of application of anhydrous ammonia	L, 7
2.20/2	N rate and time, anhydrous ammonia	Potato	Residual effects of anhydrous ammonia applied to kale in 1959	7
2.20/4	Anhydrous ammonia	Winter wheat	Anhydrous ammonia as a top dressing	L, 7
2.20/5	Anhydrous ammonia	(a) Potato (b) Sugarbeet	Use of anhydrous ammonia for these crops	L L, 7
3.2/1	P storage	Rotation	Availability of phosphate in a variety of important soil types following phosphate applications	L, W, 1, 2, 3, 4, 5, 6, 7
3.2/2	P storage	Rotation	Availability of phosphate in two soil types following phosphate applications	1
3.2/3	P rate and source	Rotation	Long-term phosphate requirements of soils with an initially high phosphate status	1, 3, 4, 5, 6
3.7/1	NPK rate	Rotation	Place of phosphate and potash in obtaining maximum crop responses to nitrogen	L
4.4/1	Sulphur requirement	Rotation	Sulphur requirement of crops over a long period	L
4.14/1	PK exhaustion	Rotations	Rotations that will best produce phosphate and potash responsiveness	L

Code No.	Title	Crop	Subject under investigation	Location
4.14/2	K exhaustion	Rotation	Residual effect of potash applied to the annual experimental area at Levington	L
4.19/1	Herbicides and insecticides	Rotation	Long-term effects of herbicide and insecticide applications in a normal farm rotation	L
4.19/2	Urea, long-term effects	Rotation	Long-term effects of urea with various biuret contents	L
4.19/3	Urea, long-term effects	Grass	Long-term effects of urea with various biuret contents	L, W
6.9/1	NPK rate	Russian Comfrey	Nutrient requirements of an unusual crop	L
8.7/1	N rate and time, take-all	Barley	Rate and time of nitrogen application in relation to take-all in spring barley	L, 7
8.7/2	NK rate, blight	Potato	Nitrogen and potash nutrition in relation to the crop's susceptibility to blight	1, 4, 6, 7
8.7/4	Time of planting, blight	Potato	Time of planting and the incidence of blight	L
8.7/5	N rate and time, take-all	Winter wheat	Rate and time of application of nitrogen in relation to take-all in wheat	L
8.7/6	Urea and Blitane sprays, blight	Potato	Foliar urea sprays and the resistance of potatoes to blight	3, 5, 7
8.7/8	N rate, time and method, blight	Potato	Late nitrogen applications to the soil or as foliar sprays in relation to blight resistance	L, 7
9.3/1	Wheat bulb fly control	Winter wheat	Aldrin and phosphate in relation to crop yield and incidence of attack	6, 7
9.3/2	Wheat bulb fly control	Winter wheat	Various incorporated insecticides combine drilled	6, 7
9.3/3	Frit fly control	Spring oat	Use of fertilizer plus Aldrin	5
9.3/4	Aldrin plus fertilizer, storage	Potato	Efficiency of Aldrin plus fertilizer after storage for wireworm control	2, 3, 5
10.2/1	Carbyne rate, seedbed	Barley	Carbyne as a pre-sowing treatment for wild oats	7
10.6/1	Carbyne and N rate	Barley	Effect of nitrogen on control of wild oats by Carbyne	7
10.6/2	Carbyne and N rate	Barley	Effect of Carbyne with and without nitrogen	L
10.8/1	Tecane, fertilizer, wild oat control	Various root crops	Residual effects of tecane incorporated in fertilizer for the control of wild oats in 1959	1, 6, 7
10.8/2	Tecane survey	Various	Tecane incorporated in fertilizer for wild oat control under a wide range of conditions including residual effects of Tecane applied in 1959	1, 2, 3, 4, 5, 6, 7

Code No.	Title	Crop	Subject under investigation	Location
10.8/6	Tecane plus fertilizer, storage	Various root crops	Efficiency of Tecane plus fertilizer after storage for wild oat control	4, 6, 7
12.1/1	K rate and source, FYM rate, tuber quality	Potato	FYM and potash source in relation to tuber quality and yield	L
12.1/2	Concentrated fertilizer, tuber quality	Potato	Effect of certain concentrated fertilizers on tuber quality	L
12.1/3	K rate and source, tuber quality	Potato	Potash source in relation to tuber quality and yield	3, 5, 7
16.1/1	Sampling technique	Kale	Optimum sampling procedure for estimating the yield of kale	L
16.1/2	Sampling technique, manganese deficiency	Pea	Optimum sampling procedure for estimating extent of manganese deficiency in peas	7
16.1/3	Sampling variability	Sugarbeet tops	Variability of dry matter and nitrogen content	L, 4, 6, 7
16.1/4	Sampling variability, sheaves	Cereals	Variability of grain content in hand gathered sheaves cut by Allen scythe	All
16.5/1	Plot size	Swede or Sugarbeet	Statistical examination of the results from various plot sizes	All
16.5/3	Plot size, Allen scythe technique	Cereals	Plot size in relation to the use of an Allen scythe for harvesting cereals plots	L
16.5/5	Plot size, combine harvester	Cereals	Plot size and type of combine for the harvesting of cereal plots	L
16.6/1	Harvesting technique	Cereals	Harvesting methods for cereal plots	L
16.6/2	Combine harvester, grain carryover	Cereals	Carryover grain from plot to plot	L
SPECIALIZED GRASSLAND				
1.1/1	N rate, cutting frequency and clover contribution	Grass	Nitrogen contribution from clover in relation to applied nitrogen and frequency of cutting	W
1.1/6	N rate, clover contribution	Grass	Nitrogen contribution from clover under grazing conditions	W
1.1/20	N rate and cutting frequency	Grass	Residual effects of nitrogen and various cutting frequencies employed in 1959	W
1.2/1	Basic slag, acid soils	Grass	Various types of basic slag	1, 3
1.2/7	P source and time calcareous soils	Grass	Sources of phosphate in relation to sward composition and yield	6
1.2/8	P source and time, acid soils	Grass	Sources of phosphate in relation to sward composition and yield	2, 5, 6
1.3/1	K time, herbage composition	Grass	Time of potash application in relation to chemical composition of spring grass	1, 4, 6
1.4/1	NP rate and P time	Grass	Time and rate of phosphate application in relation to nitrogen rate	1, 2, 5
1.5/1	NK rate and K time	Grass	Time and rate of potash application in relation to nitrogen rate	3, 7

Code No.	Title	Crop	Subject under investigation	Location
1.5/2	N rate and K time, herbage composition	Grass	Nitrogen rate and time of potash application in relation to chemical composition of spring grass	3, 7
1.6/1	PK rate	Grass	Potash and phosphate in relation to herbage production under cow grazing	W
1.6/2	PK time, early bite	Grass	Time of phosphate and potash application for the production of early bite	4, 5
1.7/4	NPK rate	Grass	Nitrogen, phosphate and potash rates in relation to yield and sward composition	1, 2, 4
2.5/1	Marginal land development	Grass	Effect of a variety of nutrients on productivity	1, 4, 5
2.5/7	Hill land development	Grass	Effect of a variety of nutrients on productivity	3
2.13/7	Sub-surface fertilizer applications	Grass	Deep placement of nitrogen, phosphate and potash on established grass	W
4.2/1	Cumulative Mg top dressing	Grass	Long-term effect of repetitive small applications of magnesium on magnesium content of herbage	1, 4, 5
6.2/1	Culm measure drainage	Rotation	Most suitable method of drainage on culm measure soils	W
6.6/2	NPK rate, N time, establishment	Grass	Nitrogen, phosphate and potash in establishment of mixed swards	5
6.7/1	NPK rate	Grass species	Nitrogen, phosphate and potash requirements of various grass species	W
7.2/2	Mg, hypomagnesaemia	Grass	Magnesium applications to grassland in relation to animal health	L
10.2/3	Buttercup control, pasture productivity	Grass	Effect on herbage productivity of buttercup control with MCPA	5
10.4/4	Herbicide, fertilizer, weed control	Grass	Residual effects of herbicide, incorporated in fertilizer for weed control in grassland	3, 4, 6, 7
10.4/5	Herbicide, fertilizer, weed control	Grass	Herbicide incorporated in fertilizer for weed control in grassland including residual effects of 1959 applications	1, 2, 3, 4, 5, 6, 7
10.4/6	Herbicide carrier, form and rate	Creeping buttercup	Form and rate of an inert carrier for herbicide when used for weed control in grassland, residual effects	7
10.4/7	Herbicide carrier, form and rate	Mustard	Form and rate of an inert carrier for herbicide	L
10.4/8	Herbicide plus fertilizer, storage	Mustard	Herbicidal efficiency after storage	L
16.1/1	Sampling methods small plots	Grass	Variability associated with various grass sampling machines	W
16.1/2	Sampling methods large plots	Grass	Variability associated with various grass sampling machines	W

Code No.	Title	Crop	Subject under investigation	Location
16.1/3	Sampling methods small plots	Grass	Variability associated with various grass sampling machines	L
16.8/1	Simulated grazing techniques	Grass	Effect on productivity of various techniques used when plots cannot be grazed	W
16.10/1	7-day changeover, milk production	Dairy cows	Use of a 7-day changeover technique	W
16.10/2	14-day changeover, milk production	Dairy cows	Use of a 14-day changeover technique	W
16.10/3	14-day changeover, milk production	Milking goats	Use of a 14-day changeover technique	W
16.10/4	Plot grazing technique	Milking goats	Suitability of milking goats for measurement of productivity from grazed plots	W
16.11/1	Establishment and management technique	White clover	Establishment and maintenance of pure white clover swards	W
16.11/2	N effect of sprayed out clover	Grass	Effect of killing clover in a sward by use of herbicide	W
16.11/3	N effect of sprayed out clover	Grass	Effect of spraying out clover in its seeding year	W
16.12/1	Grazing management, sheep	Grass	Methods of managing experiments involving sheep	L

Horticultural Experiments

The 1960 programme consists of eighty-nine experiments with 2,758 plots. The fruit experiments are mainly concerned with plant establishment, rates of nitrogen, phosphate and potash application and weed control. In glasshouse investigations on tomatoes, cucumbers and carnations, the main interests are the effects of various sources of nitrogen, rates of application of nitrogen, phosphate and potash and liquid fertilizers. Vegetable and flower experiments study nutrition, persistent herbicides, insecticides and growth inhibiting substances. The turf programme covers sward production, weed eradication and nitrogen, phosphate and potash nutrition.

Key to Locations

L	Levington	12	Western Counties
W	North Wyke	13	Eastern Counties
11	Levington Extension	14	Southern Counties
TP	Testing Panel	15	Lea Valley

Code No.	Title	Crop	Subject under investigation	Location
FRUIT				
1.1/1	N source	Strawberry	Organic and inorganic sources of nitrogen	L
1.4/2	N and P source and Mg rate	Blackcurrant	Organic and inorganic sources of nitrogen and phosphate, and rate of applied magnesium and trace elements	L

Code No.	Title	Crop	Subject under investigation	Location
1.7/2	NPK rates and time of application	Blackcurrant	Fertilizer rates and time of application in relation to flowering, fruiting, disease incidence and tissue composition	L
1.7/3	NPK rates and time of application	Strawberry	Fertilizer rates and time of application in relation to flowering, fruiting, disease incidence and tissue composition	L
2.9/2	Chelated iron and correction of iron deficiency	Apple	Correction of iron deficiency by foliar and soil applications of chelated iron	13
2.14/1	Nutrient exhaustion	Blackcurrant	Specific nutrient deficiency levels, the effect of muriate of potash and of not mulching	L
2.14/2	Nutrient exhaustion	Culinary Apple	Specific nutrient deficiency levels	L
2.14/3	Nutrient exhaustion	Dessert Apple	Specific nutrient deficiency levels	L
2.14/4	Nutrient exhaustion	Pear	Specific nutrient deficiency levels	L
5.5/1	Mulching and N requirement	Blackcurrant	Rates of application of nitrogen with and without straw mulch	L
5.5/2	Mulching and N requirement	Blackcurrant	Rates of application of nitrogen with and without straw mulch	L
6.6/2	Establishment	Dessert Apple	Methods of establishment	L
6.6/3	Establishment	Pear	Methods of establishment	L
10.2/1	Herbicide and phytotoxicity	Blackcurrant	Degree of weed control and phytotoxic effects	L L
FRUIT				
10.2/2	Herbicide and phytotoxicity	Pear	Degree of weed control and phytotoxic effects	L
10.2/3	Herbicide and phytotoxicity	Blackcurrant	Degree of weed control and phytotoxic effects	L
10.2/4	Herbicide and phytotoxicity	Blackcurrant	Degree of weed control and phytotoxic effects	L
10.2/5	Herbicide and phytotoxicity	Blackcurrant Gooseberry Redcurrant	Degree of weed control and phytotoxic effects	L
10.2/6	Herbicide and phytotoxicity	Pear	Degree of weed control and phytotoxic effects	L
10.2/7	Herbicide and phytotoxicity	Dessert Apple	Degree of weed control and phytotoxic effects	L
10.10/1	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L
10.10/2	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L
10.10/3	Runner inhibition	Strawberry	Chemical inhibition of runner formation	L
VEGETABLES, FLOWERS, ETC.				
1.1/1	N rate, source and time	Anemone	Various nitrogen sources and times of application	W
1.1/2	N source	(a) Rose (b) Chrysanthemum	Organic sources of nitrogen	L
1.7/1	NPK rates	Anemone	NPK requirement of the anemone crop	W

Code No.	Title	Crop	Subject under investigation	Location
5.3/1	Peat type as soil improver	Lettuce	Peat types of soil improver	L
6.11/1	Irrigation spray distribution pattern	—	Distribution pattern of the 'Wright Rain' sprinkler irrigation	L
9.7/1	General purpose insecticide	Various	Phytotoxicity	L
9.7/2	General purpose insecticide	Various	Phytotoxicity	L
9.7/3	General purpose insecticide	Shrubs	Phytotoxicity	L
10.2/1	Herbicide and hormone weedkillers, total weed control	—	Total weed control with combinations of herbicides	
10.2/2	Herbicide phytotoxicity	Susceptible shrub species	Phytotoxic effects of herbicide	14
10.2/3	Herbicide and time of application	—	Total weed killer applied at different times of the year	L
10.2/6	Herbicide and moss control	—	Moss eradicant on uncultivated ground	11
10.2/7	Selective use of herbicide	Asparagus	Selective herbicidal efficiency on a specific crop	11
10.10/1	Growth inhibition	Privet	Phytotoxic levels of maleic hydrazide formulations	11
10.10/2	Growth inhibition	(a) Privet (b) Hawthorn	Growth inhibition in relation to concentration and application method	11 L
10.10/3	Growth inhibition	Hedge types	Growth inhibition and phytotoxicity when applied annually to a range of hedge types	TP
10.10/4	Growth inhibition	(a) Privet (b) Hawthorn	Growth inhibition at various times of application	11 L
10.10/5	Growth inhibition	(a) Privet (b) Hawthorn	Growth inhibition at various times of application	11 L
10.10/6	Growth inhibition	Hedge types	Growth inhibition when applied with hand syringe	L 11
GLASSHOUSE CROPS				
1.1/1	N source	Tomato	Organic and inorganic sources of nitrogen	L
1.1/2	N source	Cucumber	Organic and inorganic sources of nitrogen	L
1.1/3	N source	Tomato	Organic sources of nitrogen	L
1.1/4	N source	Tomato	Organic sources of nitrogen	L
1.5/1	NK rate	Carnation	Related nitrogen and potash requirements	L
1.7/1	NPK nutrition	Tomato	Nitrogen, potash and phosphate nutrition	L
2.6/1	pC values	Tomato	Effect on growth of low pC values	L
2.8/1	Liquid feeding	Tomato	Methods of liquid feeding compared with solid feeding	L

Code No.	Title	Crop	Subject under investigation	Location
2.8/2	Liquid feeding	Carnation	Comparison between methods of liquid feeding and two forms of solid fertilizers	L
2.8/3	Liquid fertilizer	Pot plants	Methods and rates of application	L
2.8/4	Liquid fertilizer in relation to compost type	Pot plants	Methods and rates of application in three compost types	L
2.8/5	Liquid fertilizer	Pot plants	Methods of application to pot bound plants	L
5.3/1	Peat type in propagating compost	Tomato	Effect of various peats in propagating compost	L
5.3/2	Peat type in rooting medium	Helianthemum	Effect of various peats in a rooting medium for cuttings	L
5.3/3	Peat type in rooting medium	Chrysanthemum	Effects of various peats in a rooting medium for cuttings	L
5.3/4	Peat as soil improver	Tomato	Effect of various peats in compost for tomatoes	L
5.3/5	Peat as soil improver	Tomato	Effect of various peats as soil improvers in glasshouse borders	14 15
6.11/1	Irrigation systems	Tomato	Four methods of glasshouse irrigation and their suitability for liquid feeding	L
9.7/1	General purpose insecticide	(a) Tomato (b) Zinnia	Phytotoxicity	L
9.7/2	General purpose insecticide	Pot plants	Phytotoxicity	L
9.7/3	General purpose insecticide	Tomato	Phytotoxicity	L

EXPERIMENTAL TURF

1.1/1	N source	Turf	Ureaformaldehyde in spring and summer turf fertilizers	L
1.1/3	N source and rate	Turf	Long-term effect of N sources and rates on botanical composition, incidence of disease and growth of fine turf sward	L
1.6/1	PK rate and time	Turf	Long-term effect of P and K on growth, botanical composition and disease incidence	L
1.7/2	NPK rate, sward composition	Turf	Effects of fertilizer on sward composition	L
2.8/1	Liquid fertilizer, factors affecting scorch	Turf	Liquid fertilizer, climatic and growth factors affecting incidence of scorch	L
10.1/1	Copperas in lawn fertilizer	Turf	Value of copperas in lawn fertilizer	L
10.2/1	Herbicides	Turf	Time and rates of application in relation to clover control	L

Code No.	Title	Crop	Subject under investigation	Location
10.2/2	Herbicides	Turf	Presowing selective herbicide applications and sward establishment	L
10.2/3	Herbicides	Turf	Aerosols in relation to spot killing of weeds	L
10.2/4	Herbicides	(a) Turf (b) Lettuce	Composting of grass mowings taken from swards treated with selective herbicides	L L
10.2/5	Herbicides	Turf	Selective herbicides applied during rain	11
10.2/6	Herbicides	Turf	Pearlwort control by various selective herbicides	11
10.2/7	Herbicides	Turf	Comparison of two selective herbicides	TP
10.2/8	Herbicides	Turf	Herbicidal and phytotoxic properties of various herbicides	L
10.4/1	Combined liquid fertilizer and herbicide	Turf	Degree of weed control afforded by liquid fertilizer/weed killer combinations compared with powder fertilizer/ weed killer	L, 11
10.4/2	Combined liquid fertilizer and herbicide	Turf	Degree of weed control afforded by liquid fertilizer/weed killer combinations compared with powder fertilizer/ weed killer	L, 11
10.4/3	Herbicide and inorganic fertilizer	Turf	Inorganic fertilizer as carrier for selective weed killers	L, 11
10.10/1	Maleic hydrazide, rates of application	Turf	Various rates of maleic hydrazide formulations upon inhibition of growth	L
10.10/2	Maleic hydrazide formulations	Turf	Phytotoxicity	L
10.11/1	Moss eradication metallic salts	Turf	Degree of moss control with a number of metallic salts	11
10.11/2	Moss eradication, liquid herbicides	Turf	Effect of combining chemicals and various herbicides upon moss and weed control	11

Pot Experiments

The programme of the Pot Trials Unit for 1960 consists largely of the main subjects investigated in 1959 to consolidate the findings and enlarge the field of investigation. Included in the programme are (a) comparison of calcium phosphates, (b) evaluation of fertilizers containing different proportions of water-soluble and water-insoluble phosphate, (c) comparative value of particle sizes of slag, (d) investigation of the toxicity associated with urea, (e) determination of environmental factors which may influence the control of wild oats by Tecane incorporated in fertilizer and (f) technique investigations.

In addition, accommodation in the cage and glasshouses will be provided for pot experiments in connection with the work of all of the Fundamental Research Group.

Code No.	Title	Crop	Subject under investigation
Agronomic Projects			
1.1/1	N nutrition (residual)	Ryegrass	Residual availability of nitrogen from various organic sources; long-term effects
1.2/1	P nutrition	Sugarbeet	Levels of phosphate at different water stresses
1.2/2	P nutrition	Barley	Various water-soluble and water-insoluble phosphates
1.2/3	P nutrition	Mustard	Various water-soluble/water-insoluble phosphate ratios in fertilizers
1.2/4	P nutrition (residual)	Mustard	Residual value of various water-soluble and water-insoluble phosphates
1.2/5	P nutrition	Ryegrass	Ammoniated superphosphates
1.2/6	P nutrition	Ryegrass	Rate of P_2O_5 uptake from monocalcium and dicalcium phosphates
1.2/7	P nutrition	Ryegrass	Effectiveness of different phosphate rocks when ground to various particle sizes
1.2/8	P nutrition	Mustard	Effectiveness of various phosphatic fertilizers on soils of different pH
1.7/1	NPK nutrition	Mustard	Correlation of crop responses and soil analyses; British soils
1.7/2	NPK nutrition	Mustard	Correlation of crop response and soil analysis; Nicaraguan soil
2.2/1	Mg nutrition	Cereals	Effect of water supply on the uptake of magnesium by cereals
2.2/2	Mg nutrition	Cereals	Uptake of combine-drilled magnesium
2.5/1	Boron nutrition	Sunflower	Boron availability in compound fertilizers
2.10/1	Liquid seed dressings	Cereals	Possible interaction between liquid seed dressings and Aldrinated fertilizer
2.12/1	Particle size, basic slag	Ryegrass	Basic slag ground to various particle sizes
2.12/2	P nutrition	Mustard	Phosphates in granular and powder forms when incorporated with soil
2.12/3	P nutrition	Mustard	Phosphates in granular and powder forms when applied as a top dressing
2.19/1	Cyanate and guanidine toxicity	Wheat	Toxicity from cyanate and guanidine
2.19/2	Biuret toxicity	Ryegrass	Toxicity from biuret
2.19/3	Concentrated fertilizers	Wheat Barley Oats	Concentrated fertilizers in relation to seed germination and plant establishment
2.19/4	Biuret and cyanate toxicity (residual)	Wheat	Persistence of biuret and cyanate in the soil
2.19/5	Triuret toxicity	Wheat	Toxicity from triuret
2.19/6	Biuret in pelleted urea	Wheat	Possible toxicity from urea
2.19/7	Ureaformaldehyde toxicity	Tomato	Possible toxicity from heavy dressings of ureaformaldehyde
2.19/8	Nitrogen toxicity	Wheat Barley Oats	High rates of nitrogen and germination of cereals
10.8/1	Pre-emergent herbicides	Oats	Soil pH/Tecane interactions
10.8/2	Pre-emergent herbicides	Oats	Rainfall/Tecane interactions

Code No.	Title	Crop	Subject under investigation
10.8/3	Pre-emergent herbicides	Oats	Soil organic matter and the herbicidal properties of Tecane
10.8/4	Pre-emergent herbicides	Oats	Time of application and the effectiveness of Tecane
10.8/5	Pre-emergent herbicides	Oats	Persistence of Tecane in soil
16.9/1	Technique	Mustard Barley	Soil compaction and plant establishment and growth
16.9/3	Technique	Mustard Ryegrass Barley	Powder and liquid fertilizer placement
16.9/4	Technique	Mustard	Seed rate and plant population
16.9/5	Technique	Ryegrass	Seed rate and plant population
16.9/6	Technique	Barley	Seed rate and plant population
16.9/7	Technique	Mustard	Positional effects in glasshouses
16.9/8	Technique	Mustard	Seed coverings
16.9/11	Technique	Various	Magnitude of response to fertilizer in relation to crop variability
18.3/1	Soil conditioners	Mustard	Value of selected soil conditioners and improvers
Fundamental Research Projects			
50.1/2	Organic matter decomposition; response to applied N and P	Oats Tomato Mustard	Organic matter addition and decomposition in soil at different rates of N and P
50.1/3	Organic matter decomposition; response to applied N and P	Ryegrass	Effect of organic matter addition on L-values at different rates of N and P
50.1/4	Organic matter decomposition; response to applied rock phosphate	Mustard Ryegrass	Organic matter addition and decomposition in soil in the presence and absence of applied rock phosphate
53.2	L-value; phosphate equilibration	Ryegrass	Methods of establishing equilibrium between applied P^{32} and soil phosphate prior to L-value estimation
53.4/1	L-value of soils from P storage experiment	Ryegrass	Change in L-value with time of soils after very high phosphate applications in the field
53.4/2	L-value of soils from P storage experiment	Ryegrass	Change in L-value with time of soils after very high phosphate applications in two forms in the field
53.15	Plant culture under aseptic conditions; phosphate source	Various	Crops grown under aseptic conditions and with various phosphate sources
53.17	Influence of micro-organisms on level of plant assimilable phosphorus in the soil	Various	Changes in microbial activity and its influence on 'plant-assimilable' phosphate
53.19	L-value of soils from phosphate rate and source rotation	Ryegrass	Initial determination of L-value of soils from a long-term phosphate rate and source rotation
101.1/1	Effect of phosphorus supply on leaf area growth; water culture	Sugarbeet	Leaf area in relation to phosphorus supply

Code No.	Title	Crop	Subject under investigation
110.2	Experimental material; ryegrass	Ryegrass	Provision of a natural aggregate of soil and roots for laboratory investigation
110.9/4	Causes of yield variation	Barley	Growth rates of different varieties after ear emergence; response to P
115.1/3	Determination of soil phosphate status; technique	Ryegrass	Various factors on phosphorus taken up by deficient seedlings after exposure to soil
115.5	Plant culture under aseptic conditions; response to phosphorus; technique	Various	Plants grown under aseptic conditions and with various phosphorus levels in the nutrient medium

The field experiments in the provinces are planned at Levington for general agriculture and at North Wyke for specialized grassland, all being co-ordinated at Levington.

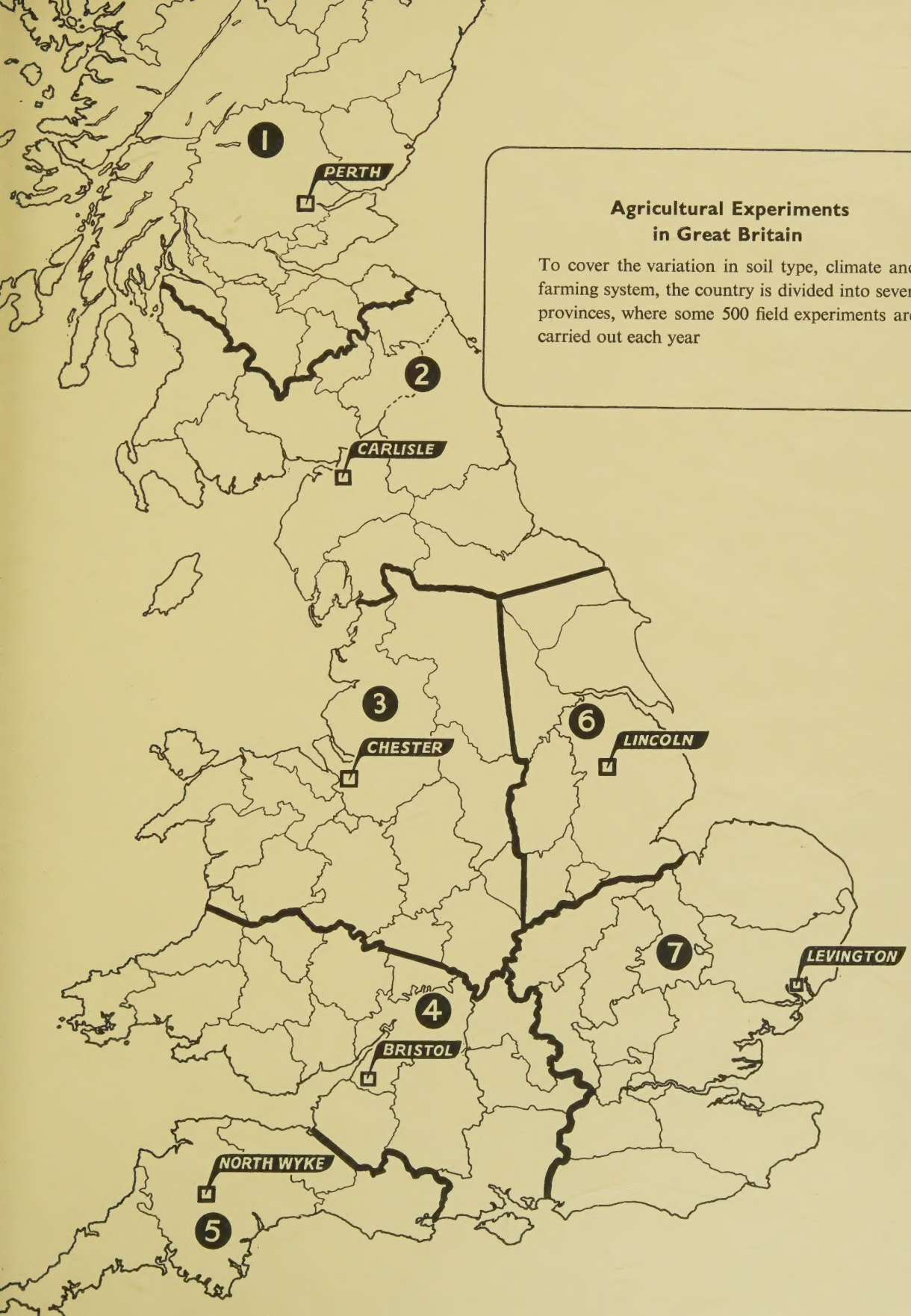
These experiments are carried out by the following Agricultural Advisers assisted by Crop Recorders, each Adviser being responsible for one of the locations into which the country is divided. In East Anglia, the South-Eastern and South-Western counties, the provincial work is done by Field Officers working either from Levington or from North Wyke.

Location			
1	Perth	J. M. Coull, Fisons Fertilizers Limited, Shore Road, Friarton, Perth.	*Perth 2956*
2	Carlisle	W. K. Letheren, The Poplars, Houghton, Carlisle, Cumberland.	*Carlisle 23155*
3	Chester	I. R. English, Field House, Okell's Lane, Cuddington, Northwich, Cheshire.	*Sandiway 2162*
4	Bristol	J. D. Edward, Fisons Fertilizers Limited, 11/19 Wine Street, Bristol.	*Bristol 27191/4*
5	South West	D. W. T. Brough, North Wyke Experimental Station, North Tawton, Devon.	*North Tawton 282*
6	Lincoln	W. A. G. Mason, Fisons Fertilizers Limited, Carholme Road, Lincoln.	*Lincoln 27421*
7	East Anglia, South East.	A. M. Ainsley, F. W. Dunnett, Levington Research Station, Levington, Ipswich, Suffolk.	*Ipswich 76911*

Field experiments on horticultural crops are occasionally carried out in the provinces, but the majority are sited at Levington or in East Anglia (Location 13).

The Horticultural Advisers located in the provinces are:

Location			
12	Western Counties	C. P. Quarrell, 37 Northwich Close, Worcester.	*Worcester 27634*
14	Southern Counties	J. C. Bush, 12 St. Matthew's Road, Weeke, Winchester, Hants.	Winchester *3171*
15	Lea Valley	C. Evans, 'St. Davids', Falconers Park, Sawbridgeworth, Herts.	*Sawbridgeworth 3293*



Agricultural Experiments in Great Britain

To cover the variation in soil type, climate and farming system, the country is divided into seven provinces, where some 500 field experiments are carried out each year

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